CLIMBER ACCESS TRAIL MAPPING & GPS VISITOR TRACKING

IN INDIAN CREEK, UTAH

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Natural Resource Recreation Planning & Management
Project Report
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EXECUTIVE SUMMARY

Project Conclusions

- The sampled population of climbers in Indian Creek was found to be relatively homogenous in perceived skill level, experience use history, specialization, and demographics.
- Since the participants were found to be homogeneous, finding a 'type' of climber who may spend more time at any one location throughout the day was not possible.
- Since the participants were found to be homogeneous, finding a 'type' of climber who may be contributing most to informal trails was not possible.
- It was found that most participants were confused at key locations on roads and trails.
- In order to lessen confusion about the locations of climbing walls and trails, both narrative and arrow signage should be placed at key locations throughout Indian Creek to direct climbers.

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ABSTRACT

Corporations follow employee driving habits, biologists track wildlife, and parents confirm the location of children. The Global Positioning System (GPS) has become such an integral part of modern life that it is no surprise that researchers can now monitor where recreationists travel and how much time they spend at certain locations. In GPS Visitor Tracking (GVT), a device that uses GPS is carried by a participant and records the location of the participant at regular intervals. Researchers can then use GPS data to view the temporal and spatial distribution of recreationists in complex recreation environments.

One such complex recreation environment that has increased in popularity in recent years is Indian Creek, Utah. Because of the perfectly parallel vertical fissures in Wingate sandstone walls, this area has become an international rock climbing destination. Rock climbers are drawn to the unique and difficult climbs as well as the open space and primitive feeling that Indian Creek provides. This newfound popularity has brought higher frequencies of climbers along with new management concerns, including land degradation, impacts to natural resources, and crowding at popular climbing areas. The landscape of Indian Creek consists of vast stretches of flat desert canyons separated by towering sandstone walls. This topographical complexity makes the task of protecting natural resources while facilitating access difficult. Consequently, the management groups of Indian Creek are beginning to realize that this increase in popularity is quickly causing natural and social impacts and that gathering information is a necessary step to understand the full scope of the issues.

The purpose of this study was to inform future land management decisions by analyzing current trail systems and comparing rock climbers' characteristics to their temporal and spatial patterns of use. The primary investigative questions for this study were 1) Do different types of rock climbers travel in different ways, 2) Which rock climbers contribute to informal trails, and 3) Spatially, how do climbers spend their time in Indian Creek?

This research was important and necessary because it informs land management decisions for future trail modifications and improvements, climber education programs, and land exchanges in Indian Creek. This research contributes to future research by developing GPS tracking methods, provides new literature that incorporates geography, recreation, and natural resource management, and offers a foundation for GPS use in future investigations for various recreation and leisure activities.

Methods

All study participants were asked to complete a questionnaire with items capturing demographics, specialization, self-perceived skill level, and past use history. To analyze social data from the questionnaire, the researcher used descriptive statistics after standard data cleaning and ensuring adequate validation of the measurements. A K-means cluster analysis was used to attempt to divide climbers based on their skill level, specialization, experience use history, and demographics.

Component 1 focused on analyzing climbers' temporal and spatial patterns of use by tracking climbers for a 24-hour period. Climbers were intercepted at their campsites in order to allow for the natural dispersion of participants to their desired climbing area. To analyze GPS data from

Component 1, tracks from each participant were clipped coming to and from the campground, to and from the parking area near the climbing wall, and to and from the climbing wall. This method provided the times at each of these locations so that the total amount of time spent at camp, driving, at parking areas, hiking to the climbing wall, and at the climbing wall could be averaged and compared to the length of daylight hours as well as the entire 24-hour period.

Component 2 focused on analyzing informal trail use at five climbing walls of interest. Climbing walls of interest are areas with special management concerns including land degradation, resource overuse, informal trail proliferation, and crowding. These five walls were chosen based on the highest use areas from Component 1. The researcher defined the 'who' based on the questionnaire responses to degree of specialization, self-perceived skill level, and past use history. To analyze GPS data from Component 2, only participant tracks that included sections of informal trails were to be compared to the questionnaire data. Study participants were to be split into four groups based on the amount of time spent on informal trails, and an ANOVA test using four groups was going to allow the researcher to determine who (demographically and recreation characterizations) contributes most to informal trails. The results, however, did not allow this analysis.

Results

The study population was found to be relatively homogeneous in demographics, specialization, self-perceived skill level, and past use history. Therefore, finding a 'type' of climber who contributes most to informal trail proliferation or spends the most time hiking was not possible. In Component 1, it was found that most climbers spend the majority of their daylight hours at the climbing walls and they spend more time driving than hiking. Originally in Component 2, a series of K-Means Cluster and ANOVA tests were performed to compare groups of climbers who spent differing amounts of time on informal trails; however, the homogeneous results did not allow the researcher to divide participants into groups. Therefore, Component 2 still focused on analyzing informal trail use at the five most used climbing walls, and recommendations were make for signage based on the GPS Visitor Tracking.

Conclusion

Studies, such as this one, that examine, assess, and monitor recreationists' impacts to protected natural areas and their relationships to influential factors can help identify and evaluate resource impacts, facilitate the understanding of causes and effects, and provide insight into the prevention, mitigation, and management of problems (Marion, 1998; Leung & Marion, 2000). Since spatial and temporal distributions of use contribute to the extent of recreation-related resource impacts (Hammitt and Cole, 1998), information gleaned from GPS Visitor Tracking in Indian Creek, Utah provides the management of Indian Creek and other natural areas with climber distribution at climbing areas as well as insight into the causes of natural resource impacts.

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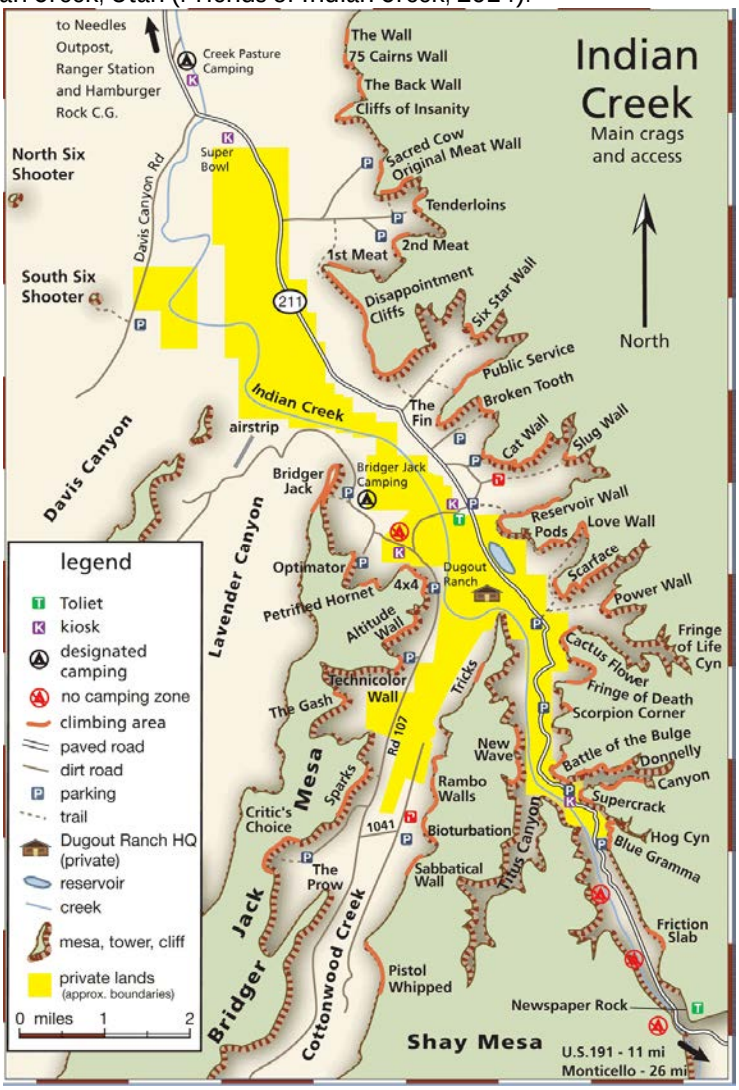
1 CHAPTER 1: INTRODUCTION

Indian Creek Corridor is located 15 miles north of Monticello, Utah along Highway 211, which leads to the Needles District of Canyonlands National Park. This corridor contains archaeological and cultural resources such as the petroglyphs at Newspaper Rock and recreation opportunities such as hiking and rock climbing. The Bureau of Land Management (BLM) manages the majority of this 26 mile section as a Special Recreation Management Area (SRMA), but this area also consists of land that is state and privately owned. The BLM issues permits for cattle grazing and recreation guiding and also cares for several facilities in Indian Creek SRMA including roadways, three camping areas, and five areas with pit toilets. The main private landowner is the Nature Conservancy, which in 1997 bought the Dugout Ranch, where Heidi Redd has run the Indian Creek Cattle Company for over forty years. Heidi was given a life lease of 25 acres so the ranch continues to operate. The Nature Conservancy manages this land to fulfill three stewardship goals: 1) to preserve the property's ecological and open space features, 2) to use the property as a resource for ecological research and natural history interpretation, and 3) to continue a historic ranching operation with the least impact. The Indian Creek Cattle Company holds grazing permits through much of Indian Creek SRMA on BLM land.

Because of the vertical fissures in the Wingate sandstone walls that line this corridor, Indian Creek has become an international rock climbing destination in recent years. Rock climbers are drawn to the unique and difficult climbs but also the primitive Wild West. The newfound popularity has brought higher frequencies of rock climbers along with new management concerns, including land degradation, impacts to natural resources, and crowding at popular climbing routes. As interest in rock climbing grows, land managers of popular rock climbing areas are faced with the complicated task of protecting natural resources while facilitating access. Since the land is complex with vast stretches of flat desert canyons separated by towering sandstone walls, the topographical complexity makes the task of managing rock climbers difficult. An overview of Indian Creek and the climbing areas can be seen in Figure 1.

Figure 1a: Map of Indian Creek, Utah (Friends of Indian Creek, 2014).



1.1 PURPOSE, OBJECTIVES, & PRIMARY INVESTIGATIVE QUESTIONS

The purpose of this study was to inform future land management decisions by analyzing current trail systems and comparing rock climber characteristics to their temporal and spatial patterns of use.

The project objectives included:

1. To provide the BLM with GPS data from climber access trails in Indian Creek
2. To develop a map of recreation resources and access trails
3. To identify the temporal and spatial distribution of rock climbers
4. To identify informal trails at five climbing areas and characterize the type of rock climbers that may be contributing to these trails

The primary investigative questions for this study were:

1. Do different rock climber types travel in different ways?
2. Which rock climbers contribute to informal trails?
3. Spatially, how do climbers spend their time in Indian Creek?

In order to address the research purpose, objectives, and primary investigative questions, this research involved several methods. First, the researcher used GPS to map over fifty formal and informal access trails to climbing walls in order to inventory current formal and informal trail locations. This step satisfied the objectives of providing the BLM with GPS data from climber access trails and supplied the necessary data to create a map of recreation resources. Second, the researcher performed a two-component climber use study by coupling GPS tracking of participants with a questionnaire. The first study component focused on analyzing the temporal and spatial patterns of use by tracking climbers for a 24-hour period. This component provided the researcher with temporal and spatial distribution data to answer the question of where rock climbers spend their time in Indian Creek. The second study component focused on analyzing informal trail use at five climbing walls of interest. This component allowed the researcher to compare trail locations and questionnaire data and provided insight to the questions 'Which rock climbers contributes to informal trails?' and 'Do different rock climber types travel in different ways?'.

1.2 THE PROBLEM

Although outdoor recreation is often considered to be nonconsumptive use, over time it inevitably alters the environment (Cole, 2004). Since the human and natural worlds are deeply intertwined, integrating social and ecological research is necessary for a better understanding of recreation impacts. This research falls into the category of recreation ecology, which aims to understand, examine, assess, and monitor recreationist impacts (Marion, 1998). This knowledge can help identify and evaluate resource impacts, facilitate the understanding of causes and effects, and provide insight into the prevention, mitigation, and management of problems (Leung and Marion, 2000).

Currently, the Monticello Field Office of the Bureau of Land Management (Monticello BLM) is realizing the popularity of this area to the rock climbing community. The Monticello BLM is also realizing how this newfound popularity is quickly causing various impacts, natural and social, and that gathering information is a necessary step to understand the full scope of the issues.

This research provides the BLM with a solid base of information on rock climber time-use and potential areas of overuse. With severe overuse, historical, cultural, and natural resources become

threatened, which can lead to direct management strategies. These types of management strategies can lead to recreationist dissatisfaction. By informing management decisions with valuable data such as accurate recreationist time-use information, management can make appropriate decisions while allowing for continued access and sense of freedom for recreationists.

Studies, such as this one, that examine, assess, and monitor recreationist impacts to protected natural areas and their relationships to influential factors can help identify and evaluate resource impacts, facilitate the understanding of causes and effects, and provide insight into the prevention, mitigation, and management of problems (Marion, 1998; Leung & Marion, 2000). Since spatial and temporal distributions of use contribute to the extent of recreation-related resource impacts (Hammitt and Cole, 1998), information gleaned from GPS tracking rock climbers in Indian Creek, Utah will provide management of Indian Creek and other natural areas with typical climber distribution at climbing areas as well as insight into the causes of natural resource impacts.

Since traditional methods of collecting spatial and temporal data can be inaccurate and burdensome to both the researcher and the participant, GPS tracking of recreationists provides more precise, accurate, and reliable data that is not as labor intensive as traditional methods (Hallo et al, 2012). In GPS visitor tracking (GVT), a device that uses the Global Positioning System is carried by a study participant in order to record the location of the participant at regular intervals. GVT has been a proven method for understanding the temporal and spatial distribution of recreationists in complex recreation environments.

1.3 BLM'S TRAIL MANAGEMENT SYSTEM

In the National Trails System Act of 1968, Section 3(a), Congress designated three classifications of trails for public use – 1) National Historic Trails, 2) National Scenic Trails, and 3) National Recreation Trails. The Bureau of Land Management (BLM) manages over 6,000 miles of public use trails that are classified within the National Trails System (BLM, 2009). However, the majority of trails on BLM land do not fall into the National Trails System Acts designations. More than 16,000 miles of multiple use trails are distributed over approximately 258 million acres of BLM land. The BLM manages trails in accordance with the BLM Land Use Planning Handbook as well as other BLM Directives Systems documents. Each Field Office also has its own goals and objectives for managing their land in their current Resource Management Plan (RMP). Two internal databases are used as management tools for the extensive BLM trail system – the Facilities Assets Management System (FAMS) and the Recreation Management Information System (RMIS).

Since many trails in Indian Creek have not been accurately recorded and included in these databases, the researcher recorded accurate GPS readings on the location of climbers' trails in order to provide a foundation for the future management of Indian Creek.

1.4 RATIONALE

In any research, the researcher not only wants the reader to understand what he plans to do, but also *why* the research is being done at all (Maxwell, 2012). The rationale of a study is meant to convince the audience that the study is worth doing (Sirakaya-Turk, 2011). A rationale must be meaningful, well-developed, defensible, clear, and accurate in order to be convincing to readers (Alasuutari et al, 2008). The rationale for the significance of a study can be achieved if 1) it will fill a gap in the body of knowledge and literature, 2) it will answer an unanswered question or solve a problem that has not been solved, and/or 3) the outcome of the study will result in a finding that is important to the field (Sirakaya-Turk, 2011).

This research provides the management of Indian Creek with an understanding of the temporal and spatial distribution of climbers, maps of the locations of climber access trails and several informal trails, and insight into types of climbers who may be contributing to informal trails. With the fragility of the desert landscape and increasing interest from rock climbers, Indian Creek is facing the pressures of overuse, including land degradation, impacts to natural resources, and crowding. This research provides managers of Indian Creek with strategies to help prevent land degradation and impacts to natural resources while maintaining access to an area that is beloved by climbers. This research *is important and necessary because it informs land management decisions for future trail modifications and improvements, rock climber education programs, and land exchanges in Indian Creek, while providing valuable information for other recreation areas as well*.

This research *contributes to future research by developing GPS tracking methods, provides new literature that incorporates geography, recreation, and natural resource management, and offers a foundation for GPS use in future investigations for various recreation and leisure activities*. While researchers have performed GPS tracking on recreationists in the past (Hallo et al, 2012; D'Antonio et al, 2010; Lai et al, 2007), few have coupled GPS data with social data from questionnaires. Performing GPS tracking and collecting questionnaire data at the same time allows for better understanding of spatial distribution, use intensity, and travel patterns in relation to recreationist characteristics like motivations, desires, and ability level (Beeco & Brown, 2013). Since the human and natural worlds are deeply intertwined, integrating social and ecological research is necessary for a better understanding of recreation impacts.

Leisure and recreation are important to our society for a variety of reasons including physical and mental health, satisfaction with life, social interaction, and family cohesiveness (van Baak et al, 2003; Edington et al, 1995; Crandall, 1979; West & Merriam, 2009). In recent years, rock climbing has only increased in popularity both as a recreation activity and as a competitive sport (Sheel, 2004). Although outdoor recreation is often considered to be nonconsumptive use, over time it inevitably alters the environment (Cole, 2004). Because of the popularity of rock climbing, places like Indian Creek are becoming impacted in various ways, including land degradation, impacts to natural resources, and crowding. By providing information on rock climber characteristics, informal trail use, and time-use at Indian Creek, this research *hopes to contribute to continued access for rock climbers and other recreationists while maintaining an acceptable impact to natural resources in many climbing and recreation areas*.

1.5 KEY COMPONENTS

As seen in Table 1, the researcher used GPS, GIS, GPS Visitor Tracking, and a questionnaire to address the project goals and objectives.

Table 1a: Key Components of the study

Component	Importance
GPS	In the past, collecting temporal and spatial data involved having participants draw their paths and record times on blank maps, which is time-consuming and generally unwelcomed by recreationists. Since Global Positioning System (GPS) data collection has become accessible, the task of monitoring spatial and temporal use is easier for the study participant and the researcher and can allow for more accurate data collection.
GIS	Geographic Information Systems (GIS) assisted with data analysis, map creation, and time-use analysis.
GPS Visitor Tracking	Small GPS data loggers were used to 'track' rock climbers during their daily activities in Indian Creek. This technology allowed for an accurate view of the temporal and spatial use of the study area.
Questionnaires	Most studies that have used GPS tracking of recreationists have focused on monitoring the spatial and temporal distributions (Hallo et al, 2012; D'Antonio et al, 2010; Meijles et al, 2013). These studies prove that GPS units are capable of providing the information necessary in understanding how social trails develop. Merging GPS tracking along with questionnaires and social construct data in this study allowed for a deeper knowledge of how social trails develop, what types of rock climbers contribute to social trails, and where social trails are likely to form.

2 CHAPTER 2: SYNTHESIS OF LITERATURE

2.1 TRAILS

A trail is a path or track through rough country, such as forest, that is made of a dirt or stone surface for the passage of people or animals. Trails are the foremost system for recreationists to access desirable locations. Past studies have shown that only about 15 to 20 percent of recreationists travel off trails in most areas, and if they do travel off trail, these distances are usually minimal (Lucas, 1978). Trails are used by people as a means to travel from one location to another. In recreation, trails allow recreationists access to nodes, which are destination areas or locations of interest (Hammitt & Cole, 1998). Nodes could include campsites, a scenic overlook, or a water source. Recreationists depend on trail systems for safety and direction. This dependence can be a powerful tool for directing use patterns and even influencing the experiences of the recreationists (Hendee et al, 1978).

Recreationists vary by activity, and, therefore, different recreationist groups have varying reasons for using trails (Manning, 2011). The primary goal of backpacking is to hike for a long distance in order to get to a location of interest. The backpacker then camps in that location of interest and continues on the trail the following day. The primary goal of mountain biking is to ride a bike on trails. The goal could possibly be to get to a scenic location, but riding on the trail may be the primary objective as well. For these two recreationist groups, the trail is a driving factor of the recreation experience. On the other hand, the primary goal for recreationists is to climb rocks. While the trail is used to get from the car or the campsite to the rock, the integrity of the trail is not the reason to recreate and is not the biggest part of the recreation experience.

2.2 INFORMAL TRAILS

Many low impact philosophies have become commonplace in the vocabulary of recreationists: Leave No Trace, minimum impacts, leave only foot prints, take only photographs. This verbiage signifies that individuals and groups are capable of avoiding or minimizing impacts to natural areas with the proper equipment and knowledge (Pigram, 1983).

Informal or social trails are trails that exist that were not planned, created by, or officially recognized by the land managers. Informal trails can occur as just one trail segment or can be multiple linked. In areas of high use, they can often be made up of hundreds of intertwined trails that create a web of socially used paths. Informal trails are often created near already managed trails, in meadows, in muddy stretches of trail, and on switchback to create a more direct route

(Cole et al, 1987). These types of trails can also occur near nodes such as campsites, viewpoints, and water sources (Buckley, 2004). These trails inevitably cause harm to the natural environment.

Even well planned trails can cause impacts such as soil compaction and vegetation loss and can fragment habitat and disrupt wildlife movement to the natural environment, but for informal trail development, these impacts are amplified (Pickering & Growcock, 2009). Informal trails dissect large landscapes into smaller sections, which can result in altered hydrology and soil moisture, reduced habitat, and the invasion of invasive species using informal trails as channels for travel and dispersion (Forman, 1995). Informal trails can also create barriers for certain species, which reduces the ability of animals to disperse seeds and reduces the rate of animal movement on the ground (Holmquist, 2004). The severe nature of informal trail impacts were brought to the U.S. National Park Service's attention when the VERP management framework selected the proliferation of informal trails as in impact indicator due to the apparent ecological and social significance (NPS, 2004).

2.3 MOTIVATIONS BEHIND INFORMAL TRAIL DEVELOPMENT

In order to begin understanding the motivations behind informal trail development, it is important to understand motivations to recreate. Maslow (1954) theorized that everyone possesses only five basic needs: physiological needs, safety/security needs, belongingness/love needs, and self-actualization needs. This theory was simply the needs that pertained to all aspects of life, but it is important in understanding deeper recreation motivations. While many words can be used to describe why people are driven to recreate, motivations for leisure and recreation can be pared down to include the following 1) escape, 2) enhancing relationships, 3) personal mastery, and 4) winning (Dillard & Bates, 2011). Neulinger (1974) hypothesized that leisure had two dimensions: 1) perceived freedom (i.e. the activity had to be undertaken freely, without constraint or compulsion) and 2) intrinsic motivation, the concept that satisfaction arises from engaging in the leisure activity itself instead of having an external reward. These natural motivations give humans reason and incentive to do something or behave a certain way.

Recreationists can also be placed into the categories of 'casual' and 'serious' in terms of their leisure choices. Serious recreation captivates its participants with complexities and challenges, while casual recreation requires little or no training. Rock climbing is considered a serious, high risk, extreme sport (Self et al, 2007). Studies that have researched motivation in high risk sports have found that these people tend to have high self-efficacy, high risk taking behaviors, and a desire for

mastery. They also have the ability to inhibit the influences of anxiety, fear, and the recognition of danger (Slanger & Rudestam, 1997).

While there may be an awareness of the damages that informal trails can do to our natural resources, the proliferation of informal trails appears to only continue. So why do people make social trails and what are the primary drivers for doing so? Social trails begin with just one person leaving the main trail in order to accomplish something. This can be to find solitude, find firewood, get somewhere faster than the current trail, or go somewhere that a trail does not already go. Once one person leaves the existing trail system, the grass is compressed or the dirt is scuffled which can trigger the next person who uses the trail to question whether or not to use the same newer informal trail (Manning, 2011).

Since the trail is not the main source of recreation for recreationists, it is possible that less thought goes into the journey to the climb than the journey itself. A trail is simply a means to an end for a rock climber, so the importance of the trail integrity and structure does not matter as much as the importance of a climb. Many trails to climbing areas are categorized as 'climbers' trails.' When rock climbing started becoming popular, most climbers' trails were informal trails that were developed over time by climbers hiking straight up a hillside to the rock wall. Since the motivation behind recreationists is to climb, making the approach hike the shortest amount of time and distance allows for more time spent climbing. Since trails that occur on the fall line of a hillside are susceptible to erosion, most climbers' trails are not desirable and are in need of management and added switchbacks. The strong personality traits and motivations of climbers could also contribute to informal trail proliferation (Kerr, 2014). Since the end goal is to climb, the distraction of seeing a rock wall but not quickly and easily seeing a formal trail could force a recreationist to forge his own path.

2.4 Spatial Analysis of Informal Trails

Since informal trails are often widespread throughout a landscape and are quite variable in structure, the development of monitoring protocols for informal trails and their associated indicators has been difficult (Manning, 2011). The extensive nature of these trail systems has made assessing and monitoring inefficient (Marion and others, 2006). Spatially, these trails can widely differ in the amount of space they take up – some cover a large amount of space within a facility and are obvious while others are small and may be difficult to spot. These differences in informal trails have made them difficult to monitor and create solutions for management strategies that fit across the board. Over the years, informal trails have been monitored using one of three general

approaches – estimates, extensive field inventories, or the extraction of georeferenced imagery like satellite imagery.

Traditional methods of collecting spatial distributions of use have required study participants to track their travel routes on blank maps and record the time spent at certain locations (Hallo et al, 2012). This type of data collection only becomes unreasonable and complex when studying recreationists in complex trails systems or when trails are unmarked. Since these traditional methods of collecting spatial and temporal data can be inaccurate and burdensome to both the researcher and the participant, GPS tracking of recreationists provides more precise, accurate, and reliable data and is not as labor intensive (Hallo et al, 2012). In GPS tracking, a device that uses the Global Positioning System is carried by a study participant in order to record the location of the participant at regular intervals.

2.5 Implications for Land Managers

Since studies have demonstrated the need for data compilation over time on ecological health effects of informal trail proliferation (Leung et al, 2011), managers should note how important it is to start collecting spatial data from recreationists and continue to collect this data. A better view of the management area's needs or problem areas can be seen when looking at spatial distributions of recreationists over time. Creating well thought out information and education techniques specifically targeting the management area's recreationist groups can assist the on-the-ground effort in informing recreationists about the issues related to informal trails. Creating school education programs is another proven way to educate early and prevent informal trail creation in the first place (Browning et al, 2012).

The most important implication for land managers is to understand the types of recreationists spending time in their management zone. Oftentimes, the motivations of recreationist groups are varied by the recreation sport, age, or gender (Afthinos et al, 2005; White et al, 1991). By recognizing what specific recreationist groups are using an area, managers can begin to understand what the recreationists are motivated by and eventually why the recreationists may be creating informal trail systems. Since many informal trails are developed because a need is not being taken care of, management must allow for an open line of communication and on-the-ground visibility to their recreationists. When land managers understand how and why informal trails develop, they are able to consider for future trail construction or modifications and improvements of existing trails.

3 CHAPTER 3: METHODS

This research aimed to answer three primary investigative questions: 1) Do different rock climber types travel in different ways, 2) Which rock climbers contribute to informal trails, and 3) Spatially, how do rock climbers spend their time in Indian Creek? GPS data collection in this study had several components in order to address these primary investigative questions:

Initially, the researcher hiked and took GPS readings from the majority of the climber access trails with a Trimble Juno. GPS readings for the current recreation facilities (toilets, parking lots, campgrounds) were also taken. This step provided data of the current resources available to rock climbers in Indian Creek.

Component 1 focused on analyzing temporal and spatial patterns of use by tracking rock climbers for a 24-hour period. Climbers were intercepted at their campsite in order to allow for the natural dispersion of participants to their desired climbing area.

Component 2 focused on analyzing informal trail use at five climbing walls of interest. Climbing walls of interest are areas with special management concerns including land degradation, resource overuse, informal trail proliferation, and crowding. Originally, climbers were to be intercepted at the trailhead or parking lot of each climbing wall of interest in order to focus on travel patterns at that particular climbing wall; however, since the BLM did not have a strong sense of the most popular climbing areas, the GVT data from Component 1 was used to find the five most popular climbing areas. The researcher defined the 'who' in the research questions based on the questionnaire responses to degree of specialization, self-perceived skill level, and past use history.

All study participants were also asked to complete a questionnaire with items capturing demographics, specialization, self-perceived skill level, and past use history.

Table 3a: Study components and applicable instruments and areas of use

Component	Instrument	Focus Area or Intercept Location	
GPS Mapping of Informal Trails	Trimble Juno	Five sites determined by GVT most popular areas	
GPS Visitor Tracking for Informal Trails Analysis	Canmore	Five sites determined by GVT most popular areas	
GPS Visitor Tracking for Time-use Analysis	Canmore	• Creek Pasture Campground • Superbowl Campground • Bridger Jack Campground • Cottonwood Creek Camp Area • Primitive Camping Areas	
Questionnaire	Paper Questionnaire	• Creek Pasture Campground • Superbowl Campground • Bridger Jack Campground • Cottonwood Creek Camp Area • Primitive Camping Areas	
GPS Mapping of Climber Trails	Trimble Juno	• 1st Meat Wall • 2nd Meat Wall • 4 x 4 Wall • Battle of the Bulge Buttress • Bioturbation Wall • Blue Gramma Cliff • The Bridger Jacks • Broken Tooth • Cat Wall • Church Rock • Cliffs of Insanity • Critic's Choice • Disappointment Cliffs • Donnelly Canyon • Election Wall • Fin Wall • Forgotten Tower • Friction Slab • Fringe Walls • The Gash • The Happy Submarine • Lavender Butte • Left Rambo	• North Six Shooter Peak • The Optimator • The Original Meat Wall • Petrified Hornet Wall • Pistol Whipped • Power Wall • Public Service Wall • Reservoir Wall • Sabbatical Wall • Scarface • Selfish Wall • Shock and Awe • Sinbad Wall • Six Star Wall • Slug Wall • South Six Shooter Peak • Sparks Wall • Suburbia • Supercrack Buttress • Technicolor Wall • Vitamin D Wall • The Wall • Way Rambo

3.1 DATA COLLECTION

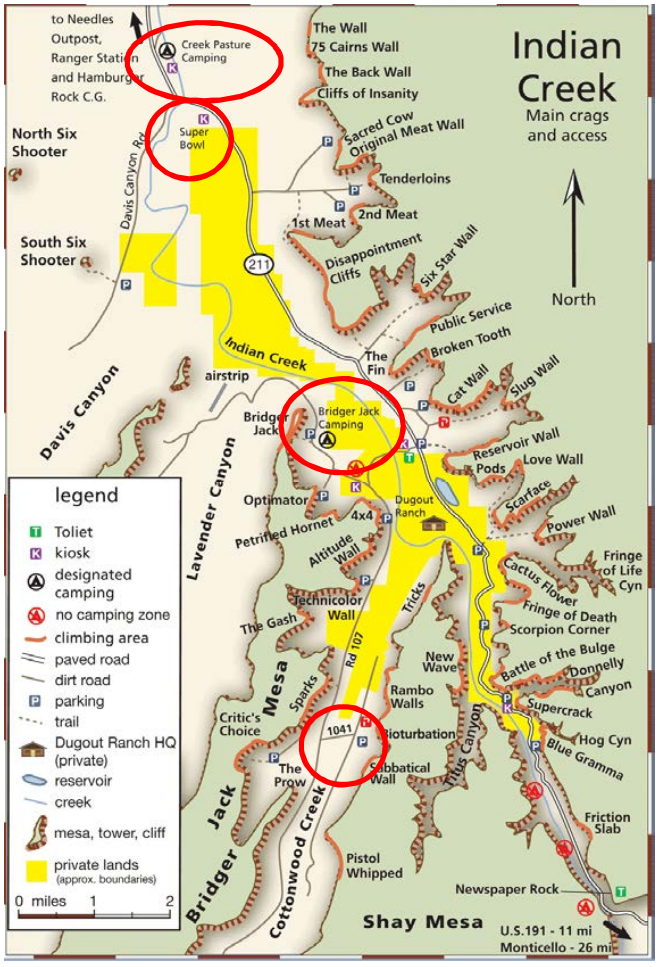
Please see the Manual of GPS Tracking Rock Climbers in Indian Creek, Utah in Appendix A for specific information on the GPS tracker's initial set-up, uploading, and data manipulation.

3.2 INTERACTION WITH STUDY PARTICIPANTS

3.2.1 INTERCEPT LOCATIONS

The first study component focused on analyzing temporal and spatial patterns of use by tracking climbers for a 24-hour period. This component provided the researcher with temporal and spatial distribution data to answer the question of where climbers spend their time in Indian Creek. For Component 1, the four main intercept locations: Creek Pasture Campground, Bridger Jack Campground, Super Bowl camping area, and the camping area along Cottonwood Creek on Beef Basin Road. These areas can be seen below:

Figure 3a: Intercept locations



The second study component focused on analyzing informal trail use at five climbing walls of interest. This component allowed the researcher to compare trail locations and questionnaire data in order to characterize the type of climber that may be contributing to informal trails as well as provide answers to the questions 'Which rock climbers contribute to informal trails?' and 'Do different rock climber types travel in different ways?'. Intercept locations were the same as Component 1.

3.2.2 *INTERCEPT SCRIPT*

Participants were approached at their campsite. They were informed about the study's purpose and objectives and expectations as participants.

Hi, my name is _____. I'm from the University of Utah. I am conducting a study of the spatial distribution of climbers in Indian Creek. I am asking that you carry this small GPS unit with you for the next 24-hours (Component 1)/for your time at this climbing area (Component 2) as well as fill out a very short questionnaire. Participation is voluntary and your questionnaire responses are confidential. Results from this study will be reported in broad statistical terms. Would you be willing to participate today?

If No: *OK. Thank you for your time. Have a good day.*

IF Yes: *OK. Thank you for agreeing to participate. Here is the GPS unit and questionnaire.*

Once the questionnaire was completed: *Thank you very much for supporting this study. Please drop this GPS unit off in this drop box attached to the campground kiosk at the end of today when you return to camp.*

Participants were asked to carry the GPS Logger on their person for the entire day. They had to be willing to participate in the questionnaire as well as carry the GPS unit. The participant had to be camping in the same location the following night in order to return the GPS tracker to the drop box.

The researcher collected personal information on the questionnaire including name, e-mail address, phone number, and campsite location in order to ensure the retrieval of the Canmore GPS units.

3.2.3 *CONTACT FORM*

The Contact Form was used to record all interaction between the researcher and climbers. After approaching and receiving a response from a climber, the researcher recorded whether the climber

agreed or refused to participate or has already participated, the participant number if he or she agreed to participate, the group size, and group type.

Figure 3b: Contact Form

CONTACT FORM_Indian Creek_March 2014

Date:_____ **Location:**_____ **Component #:** Comp. 1 – 24-hour Comp. 2 – Day use

Hi, my name is _____. I'm from the University of Utah. I am conducting a study of the spatial distribution of rock climbers in Indian Creek. I am asking that you carry this small GPS unit with you for the next 24-hours (Comp. 1)/for your time at this climbing area (Comp. 2) as well as fill out a very short survey. Participation is voluntary and your survey responses are confidential. Results from this study will be reported in broad statistical terms. Would you be willing to participate today?

IF No: OK. Thank you for your time. Have a good day.
IF Yes: OK. Thank you for agreeing to participate. Here is the GPS unit and questionnaire.
Once the Survey is Completed: Thank you very much for supporting this study. I will return to this campsite tomorrow night to retrieve the GPS unit (Study 1)/Please drop this GPS unit off in this drop box when you are leaving this climbing area (Study 2).

Agree to Participate √	Already participated √	Refuse √	Participant #	Group Type: F-Family FR-Friends D-Dog	Group size	Comments:

3.2.4 VISITOR QUESTIONNAIRE

After agreeing to participate in the study, participants filled out a short questionnaire on 5" x 7" card stock as seen below:

Figure 3c: Questionnaire Front

Name: _____ E-mail address: _____
Campsite Area: _____ Campsite #:_____ Phone #:_____

Please tell us about *your past experience* as a rock climber.

Including today, approximately how many days in the last year have you been rock climbing (in & outside)? _____
Including today, approximately how many days in the last year have you been rock climbing at Indian Creek? _____
How many total years have you been rock climbing at Indian Creek? _____
On average, what grade of climb do you typically *lead* climb in Indian Creek (N/A if you do not lead)? _____

Please indicate your rock climbing skill level.

Novice ◄	Intermediate	► Advanced
1 2 3 4 5 6 7 8 9		

Please indicate how much each description of a rock climber describes you.

	Not at all Like me ◄ ► A lot like me
Rock climbing is an enjoyable, but infrequent activity that is secondary to other travel and outdoor interests. I am not highly skilled, rarely read articles about climbing and do not own much equipment beyond the basic necessities.	1 2 3 4 5 6 7 8 9
Rock climbing for me is important, but I do other outdoor activities too. I occasionally read articles about climbing & purchase equipment for climbing. My participation in rock climbing is inconsistent and I am moderately skilled.	1 2 3 4 5 6 7 8 9
Rock climbing is my primary outdoor activity. I purchase increasing amounts of equipment for rock climbing, participate in rock climbing every chance I get, consider myself highly skilled in climbing, and frequently read about climbing.	1 2 3 4 5 6 7 8 9

Figure 3d: Questionnaire Back

Demographic Information

1. What is your zip code (or country if outside the U.S.)? _____
2. In what year were you born? _____
3. What is your gender? (check one)

☐ Male ☐ Female

4. What is the highest level of school you have completed? (check one)

☐ Less than high school ☐ Some college ☐ Graduate degree
☐ Some high school ☐ Two-year college graduate ☐ Do not wish to answer
☐ High school graduate ☐ Four-year college graduate

5. What is your race/ethnicity? (check all that apply)

☐ American Indian ☐ Hawaiian/Pacific Islander ☐ Other
☐ Asian ☐ Hispanic/Latino ☐ Do not wish to answer
☐ Black/African American ☐ White

6. Which category best describes your total household income in U.S. dollars during 2013 before taxes?

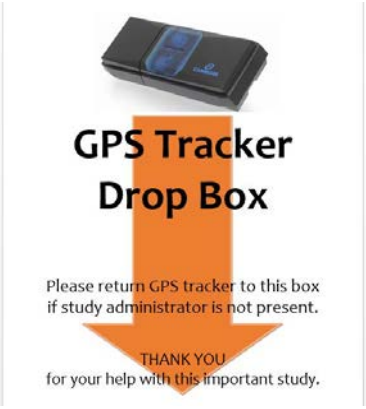
☐ Less than $24,999 ☐ $50,000 to $74,999 ☐ $150,000 to $199,999
☐ $25,000 to $34,999 ☐ $75,000 to $99,999 ☐ $200,000 or more
☐ $35,000 to $49,999 ☐ $100,000 to $149,999 ☐ Do not wish to answer

Researcher Use Only: Date: _____ Participant #: _____ Climbing Area: _____ Time: _____

The researcher reminded the participant that there were two sides to the questionnaire. After the questionnaire was completed by the participant, the researcher recorded the date, participant number (three digits starting with 001), the climbing area that the participant would be climbing at that day (if known), and the time that the GPS unit was provided to the participant.

3.2.5 COLLECTING DATA LOGGERS

Participants were asked to place the GPS loggers in a secured drop box at the campground kiosk. If data loggers were not found to be in the drop box the next morning, the research collected them in person. The drop box was locked to the campground kiosk and had a sign above it to remind participants to drop off the unit.



Secondary measures for retrieval include e-mailing and calling the participant at a later date and having the participant mail the unit to either the Monticello BLM office or the Parks, Recreation and Tourism Department at the University of Utah.

3.3 CLEANING DATA

3.3.1 CLEANING SOCIAL DATA

Before analyzing any type of data, the data was first examined for errors. It is easy to make mistakes when entering social data, and these errors pose a threat to the analysis. For example, if a number is typed twice instead of once when entering data (e.g. 55 instead of 5) the analysis would be distorted. So for this type of social data, where questionnaires are coded and entered by hand, it is important to 1) check for errors and 2) find and correct the error in the data file (Pallant, 2010). For example, for a questionnaire question on gender, there would be two options – male or female. If male was coded as '1' and female as '2', but there was an 8 in the column for gender, then that would be an obvious mistake to fix.

For this study, the researcher used standard calculations for leverage, kurtosis, and skewness to identify statistical outliers and to verify univariate and multivariate normality of the data (Tabachnick & Fidell, 2001). The researcher excluded cases from subsequent analysis due to extreme violations of multivariate normality and omitted cases for large amounts of missing data (i.e., > 50% of the questionnaire) (Kline, 2005). The researcher then applied a standard missing data analysis using EQS 6.1 to identify if the missing data points were randomly distributed ('missing completely at random' [MCAR] not achieved). Lastly, the researcher used the Expectation Maximization (EM) Algorithm to impute the missing data points if necessary (Kline, 2005).

3.3.2 CLEANING GPS DATA

GPS data must be cleaned as well, but the process of cleaning GPS data is less standardized than social data sets. As seen in Table 3b, the errors in GPS data typically occur from one of three types of interferences: 1) slow connectivity – when there is a delay while the device attempts to connect to a satellite, 2) physical structures – when satellite communication is interfered by structures such as tree cover, high buildings, or canyon walls, and 3) environments – when atmospheric conditions are not ideal (Kerr et al, 2011).

Table 3b: Interference problems with GPS units

Interference	Description
Slow Connectivity	When the device is first turned on or is trying to get a fix after a prolonged time without a connection (as on exiting a building), there is often a delay while the device attempts to gain a fix. This process is known as a cold start. The device may take a while to connect, and if the participant is moving at high speeds (50 km/hour) in a vehicle, for example, the device may constantly attempt to update the fix point, resulting in an inability to get a fix. If the participant then enters a building with limited satellite view, it can look like he or she has not traveled at all or the data are registered as missing. Devices with faster fix functions are less likely to encounter this problem.
Physical Structures	Satellite communication can be interfered with by surrounding high buildings (known as urban canyons), by tree cover, and by building materials such as tunnels or indoor locations. Older GPS models simply lost signal under such conditions. More-advanced models are able to get satellite fixes even indoors, depending on the building material and design. The result of this random interference is either signal loss or signal scatter.
Environments	GPS data can be spurious for other reasons, but a substantial number of tracks can include speeds and distances that are not plausible. Even the location of the satellites in the sky can impede signal transfer, the higher the satellite in its orbit the better the signal. Normal atmospheric conditions can also interfere with signal accuracy even in ideal conditions on earth (e.g., in a clear open space).

One type of interference from physical structures is called multipath error. Multipath error is the corruption of the direct GPS signal by one or more signals reflected from the local surroundings (Irsigler, 2001). Since rock climbers visit Indian Creek for its steep rock walls, multipath error was the most concerning of the interferences while GPS tracking this type of recreationist. The researchers considered what data were accurate and what data were erroneous and what constitutes as implausible movement for their environment and population. Only then can they make omissions when needed.

Unlike SPSS programs that can help clean social data, GPS data must be cleaned visually which is very time consuming. Beeco, Hallo, English and Giumetti (2013) examined four considerations before deleting data points: 1) distance from former and next point, 2) physical feasibility (e.g. could humans actually be in that location), 3) acceptable level of error, and 4) pattern of GPS point trail (are the points consistent with human behavior). If the GPS unit is logging every 5 seconds, and there is a mile between points, an obvious error needs to be deleted. If a point is located in the middle of a lake, it is most likely that the unit was not actually in that location. Small or repeated back and forth movements are typical of interferences from large structures. These would not

represent normal human movement and should be deleted (Kerr et al, 2011). On the other hand, data that is inaccurate because of acceptable GPS error should not be deleted (Beeco et al, 2013).

3.3.3 CLEANING GPS DATA IN INDIAN CREEK

Methods of data collection were in place to attempt to negate one of the typical GPS data errors. For the data collected in Indian Creek on rock climbers, GPS units were turned on as soon as the study coordinator arrived at the campground. The time that the GPS unit was transferred to a participant was then be recorded. After the GPS data was downloaded, GPS points recorded before the participant received the unit were omitted from the CSV file. This method allowed the GPS units ample time to locate satellite signal, and, therefore, eliminated the possibility of 'slow connectivity.'

Points were deleted based on the following criteria. If jitter caused by multipath error was observed in the data, the track was smoothed by deleting excess points. If the distance from point to point appeared to be unreasonable, points were considered for deletion. When points appeared in a location that would not be physically feasible, points were considered for deletion. If the pattern of GPS point trail appeared to not be humanly possible (e.g. the track jumps from one climbing wall to another), points were deleted.

Integrating the Indian Creek data into GIS software also allowed for the use of tools in data cleaning. Several tools in ArcMap were used to assist in observing and eliminating erroneous data. Using the point to line conversion tool helped identify points that are well outside of possible human behavior. Looking at the attribute table and using the 'view selection' option also allowed for an easy way to observe the chronology of the track and then select and delete tracks that were inaccurate.

Overall, cleaning GPS data is not as streamlined as cleaning social data, but methods are in development and testing. For this research on tracking climbers in Indian Creek, several methods and ideas on cleaning data from previous GPS research were taken into account and contributed to a more accurate representation of travel patterns.

3.4 DATA ANALYSIS

3.4.1 QUESTIONNAIRE ANALYSIS

After standard data cleaning and ensuring adequate validation of the measurements, the researcher calculated descriptive statistics. The researchers used a K-means cluster analysis in SPSS 18.0 to divide climbers based on their skill level, specialization, experience use history, and demographics.

The purpose of a cluster analysis is to divide the participants into groups (clusters) so that those participants in a cluster are more alike than participants in another cluster (Wu, 2012). In a K-means cluster analysis, an algorithm is used "that assigns data objects to the closest clusters by computing the distances between the data objects and the centroids of the clusters" (Wu, 2012, p. 178).

The results from the K-cluster analysis were then used to compare GPS tracks from participants to the locations of current trails and informal trails. Tracks across different clusters were analyzed visually for differences. The comparisons between the different clusters and GPS tracks from participants provided the researcher with insight into the questions 1) Do different types of rock climbers travel in different ways, 2) Which rock climbers contribute to informal trails, and 3) Spatially, how do climbers spend their time in Indian Creek?

3.4.2 Component 1: Time-Use Study

This component provided the researcher with temporal and spatial distribution data to answer the question 'Where do climbers spend their time in Indian Creek?'.

In order to analyze GPS tracker data, the data was downloaded to a computer with the use of the Canmore software, exported to CSV, and mapped and analyzed using ArcMaps 10.2 software.

In order to determine the amount of time spent during different activities in Indian Creek, the times that each participant started and ended their time at camp, driving, in parking lots, hiking, and climbing were recorded from the attribute tables in ArcMaps. This method provided the times at each of these locations so that the total amount of time spent at camp, driving, at parking lots, hiking to the climbing wall, and at the climbing wall could be calculated. These times were then averaged and compared to the length of daylight hours as well as the entire 24-hour period. Daylight hours were determined from noaa.com.

3.4.3 Component 2: Informal Trail Use

This component allowed the researcher to compare trail locations and questionnaire data in order to characterize the type of climber that may be contributing to informal trails as well as provide answers to the questions 'Which rock climbers contribute to informal trails?' and 'Do different rock climber types travel in different ways?'.

In order to identify the type of rock climber who contributes most to informal trails, the participants' answers to questionnaires were compared to participant informal trail use. Originally

for this study component, study participants were to be divided into four groups based on the amount of hiking time spent on informal trails. An ANOVA test using four groups would have allowed the researcher to determine who (demographically and recreation characterizations) contributes most to informal trails. However, study results did not allow for this analysis.

3.5 PILOT STUDIES

In the fall of 2013, several studies were performed in order to prepare for the Climber Access Trail Mapping & GPS Visitor Tracking in March 2014. These studies consisted of 1) a GPS Tracker Comparison Study to compare accuracy, precision, functionality, and ease of use and ultimately choose a primary GPS tracking unit that worked well in Indian Creek and 2) a Time-Use Study of Rock Climbers in Indian Creek for preliminary testing of the GPS trackers real-world functionality of the unit while being carried by rock climbers.

3.5.1 GPS TRACKER TESTING

In the fall of 2013, GPS tracking units were compared for functionality, precision, accuracy, and ease of use. Below is the report from this study which concludes why the Canmore GT-740FL was chosen as the primary GPS tracking unit for research on rock climbers in Indian Creek in March 2014.

GPS Tracker Comparison Study

In the past, collecting temporal and spatial data involved having recreationists draw their paths and record times on blank maps, which is time-consuming and generally unwelcomed by recreationists. Since Global Positioning System (GPS) data collection has become accessible, the task of monitoring spatial and temporal use is easier for the study participant and the researcher and can allow for more accurate data collection. Since units can differ by GPS chipset, manufacturer, and model and GPS tracking is an emerging technology, testing of these units by unbiased sources is essential.

This study took several of the newest GPS tracking units and tested them for ease of use, functionality, accuracy, and precision in a complex recreation setting. GPS units can function poorly in environments with dense vegetation and canyon settings. This study aimed to find which unit worked the best in the rugged setting of Indian Creek, a popular rock climbing area in Southern Utah where vast desert landscape is broken by steep sandstone walls.

Materials and Methods

The tracking units used in this study were the GlobalSat DG-100, GlobalSat DG-200, and Canmore GT-740FL Sport. The Garmin Oregon 600 was also used as part of the study since it is a more user friendly unit and has an interactive screen. The DG-200 and Canmore are newer GPS receivers; these units were compared to the DG-100, which was found to outperform other units in a similar comparison study (Hallo, 2012). Manufacturer specifications of these units can be seen in Table 1.

Units were tested for accuracy and precision by operating all four units at the same time at a geodetic questionnaire marker near Indian Creek, Utah. GPS units were set next to the marker and recorded at 5-second intervals for nine minutes. The functionality of the units were evaluated qualitatively in open desert, canyons, and next to climbing walls by walking single track trails out and back with the units. The tracks from each unit were then inspected for deviations between the out track and the back track. If the units functioned perfectly, these tracks would be one on top of the other.

Table 1: Manufacturer Specifications

	Garmin Oregon 600 	GlobalSat DG-100 	GlobalSat DG-200 	Canmore GT-740FL 
Waterproof	Yes	No	No	Yes
Size (HxWxD)	2.4 x 4.5 x 1.3	3.2 x 2.2 x 0.7	2.7 x 1.5 x 0.4	2.75 x 1.2 x 0.6
Weight	7.4 ounces	2.1 ounces	1.26 ounces	0.53 ounces
Retail Cost (2013)	$399	$75	$65	$55
Reported Accuracy Range	5, 10 or 15 m	1 to 10 meters	2.5 meters	2.5 meters
Battery type/Max. Battery life	2AA/ 16 hours	2 AA/20 hours	Built-in/20 hours	Built-in/at least 36 hours
Max. # of data points	200,000	60,000	190,000	256,000
GPS chipset	N/A	SiRF Star III	SiRF Star III	SiRF Star IV

Results

When looking at the data from all four units next to the geodetic marker, all points were located to the west, south, or southwest of the marker. The actual altitude of the marker was 1,853.47 meters above sea level. The average altitude of the Canmore was the most accurate for altitude in the geodetic marker part of the study. The Canmore's closest point was also closest to the actual

latitude and longitude of the marker, while the DG-100 had the smallest spread between its furthest points (see Figures 1 & 2 and Table 2).

Table 2: Data from Geodetic Marker Analysis

	Spread between Points	Distance from Actual	Average Altitude
Canmore	3.0 m	3.1 m	1,849.3 m
DG-100	1.5 m	3.3 m	1,853.4 m
DG-200	2.4 m	4.1 m	1,850.2 m
Garmin	3.4 m	4.8 m	1,850.9 m

Figure 1: Geodetic Survey Marker Results – Close up

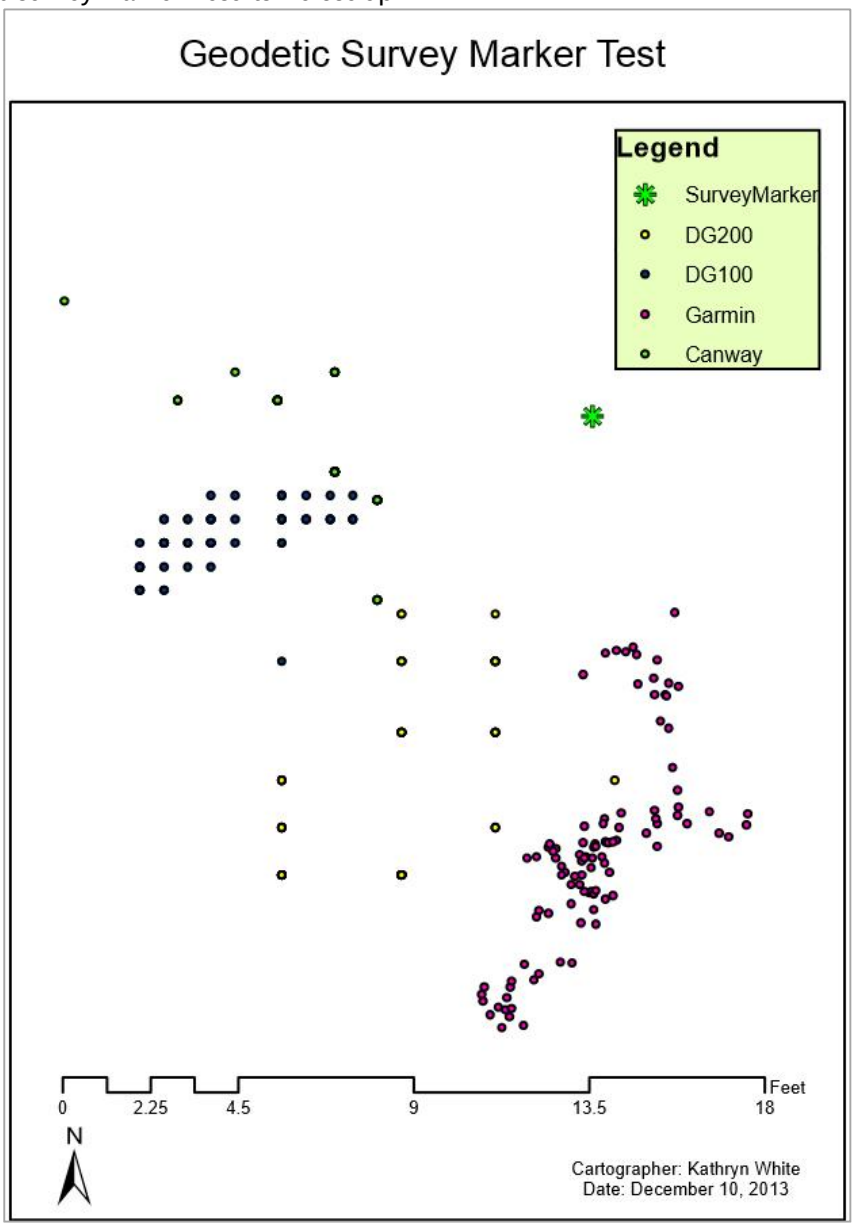


Figure 2: Geodetic Survey Marker Results – Zoomed out

Upon observation of the GPS tracks from hiking trails out and back, all units provided similar results (see Figures 4, 5, and 6). While they behave well on the flat portions of canyons, when the units get closer to steep rock wall, the instance of multipath error increases. Multipath error also appears to increase when several walls are within close range – several hundred meters – of each other. Figure 3 below provides an example of an unedited GVT where the study participant hiked to Scarface Wall (on the right side of the figure) but the GPS signal bounced to the left in the figure due to multipath error. However, when the units are used next to walls that are located on the prow of the rock buttress, the units have been found to collect data with little or no problems with the satellite signal bouncing from wall to wall.

Figure 3: Example of multipath error at Scarface climbing wall

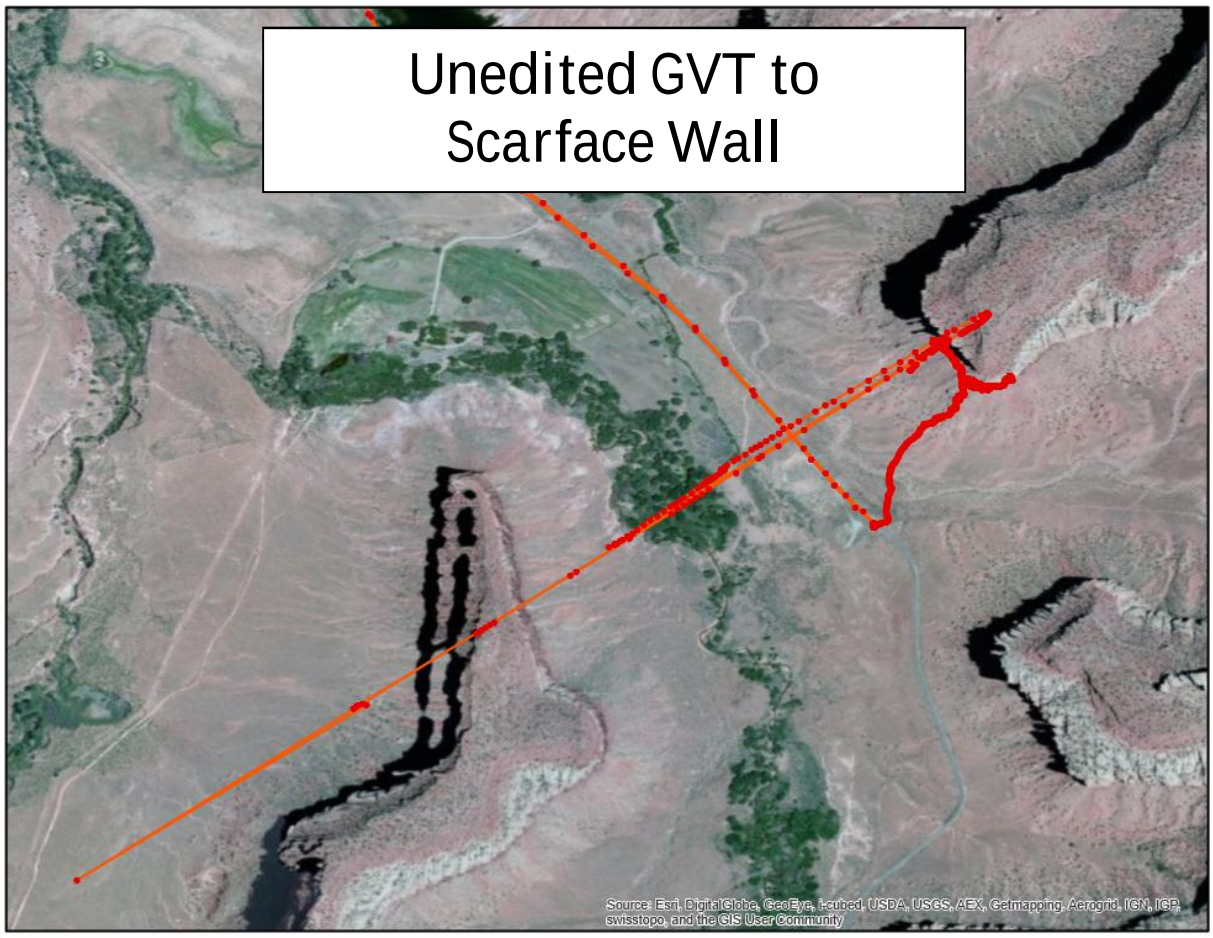


Figure 4: GPS Tracker comparison at the Battle of the Bulge Buttress

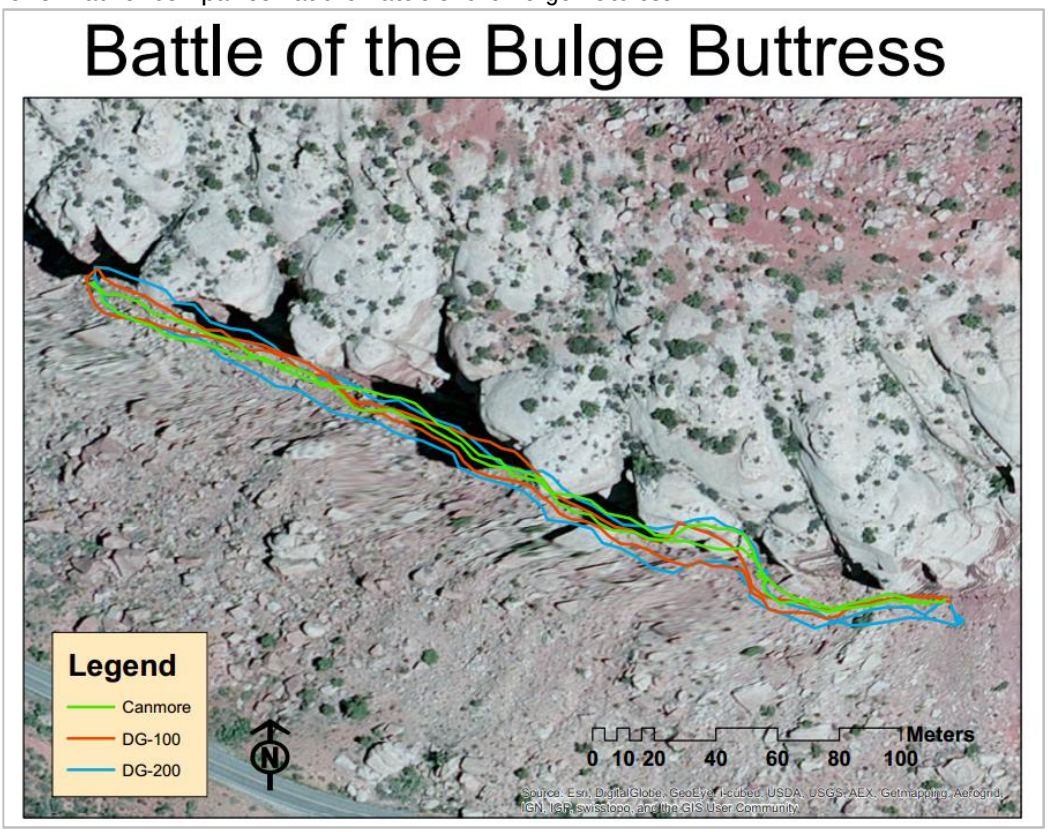


Figure 5: GPS Tracker comparison in Six Star Canyon

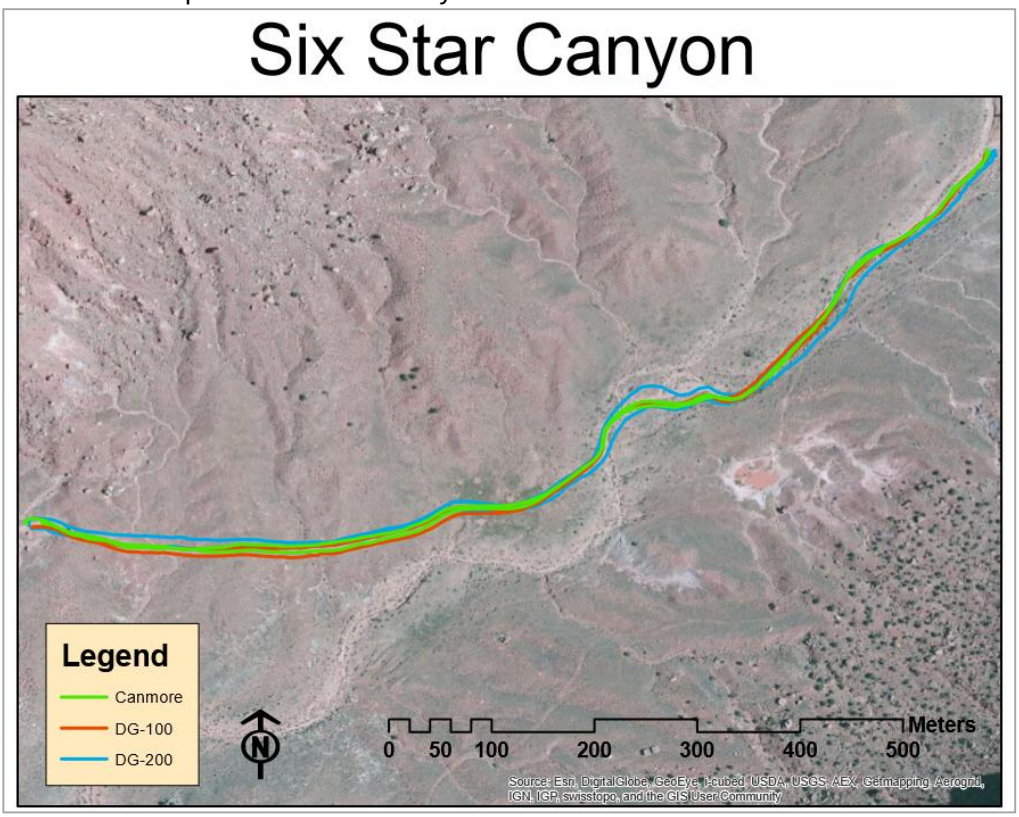
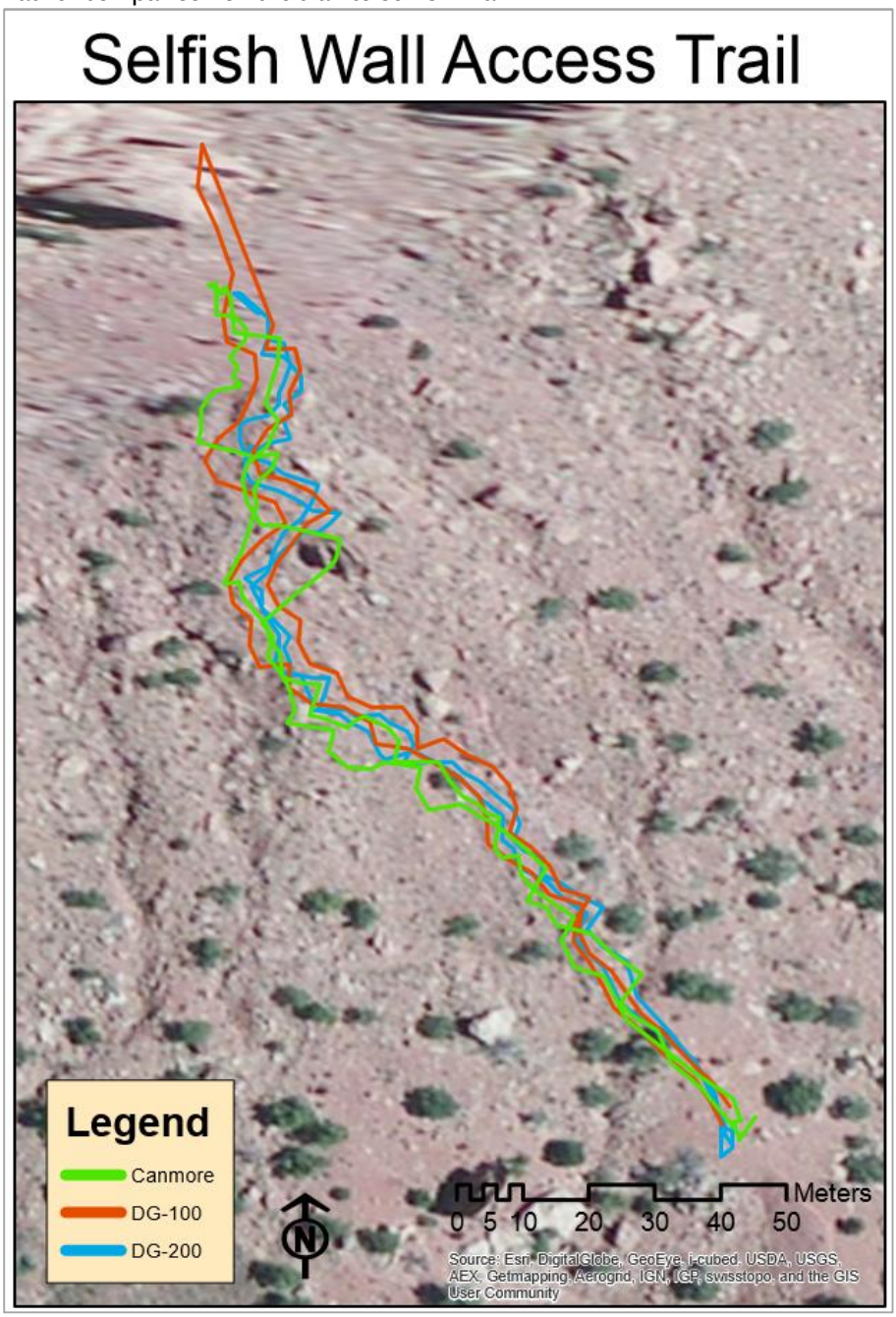


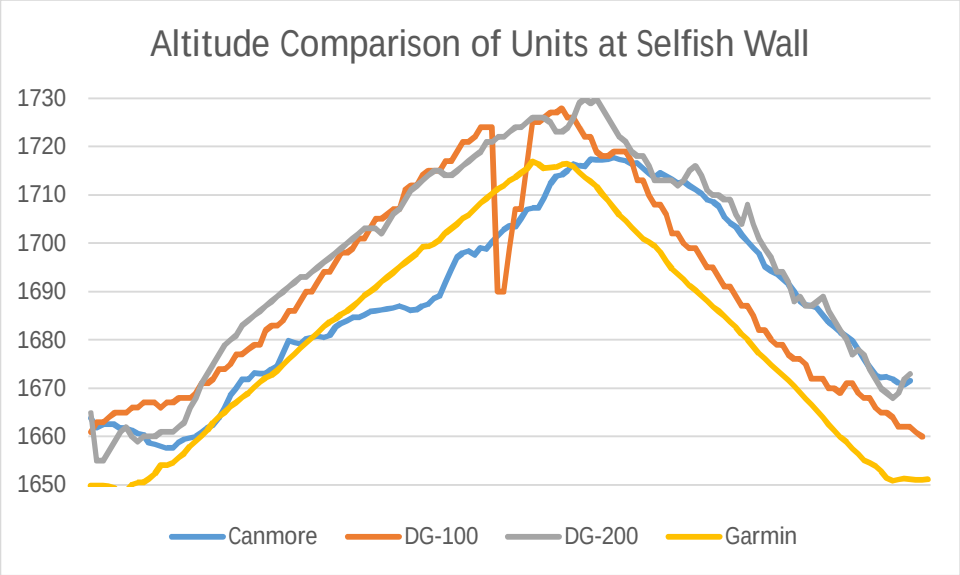
Figure 6: GPS Tracker comparison on the trail to Selfish Wall



Since altitude was collected along with latitude and longitude, each unit's altitude data were compared from hiking to and from the Selfish Wall. Since the exact altitude of this hike is unknown, a comparison of each unit's data to the actual altitude range of the hike is not possible. However, comparing the units against each other can be seen visually in Figure 7. Since the graph should appear about equal on both sides if the hike up to the wall took the same amount of time as the hike

down, the Garmin appears to be the most accurate. Each of the GPS trackers appears to have its own issues, whether that be too high or low readings or jagged points indicating inaccuracy.

Figure 7: Altitude Comparison



Discussion

While all of the units behaved similarly in the desert environment, the Canmore unit appeared to overall perform the best in this study. Of the GPS trackers, the Canmore was the easiest to use during set up, in the field, and during the downloading process. The built-in USB port is helpful in reducing cords in the field. The internal battery of the Canmore allows for less battery waste. Recharging the internal battery in the field could be challenging; however, it was found that if the DG-100 was impacted during climbing, the unit's AA batteries can be jostled causing the unit to shut down. Since solar power options have become less expensive and more available in the past few years, recharging units with internal batteries is simple. The Canmore also has a motion detector built-in that puts the unit in stand-by mode when it is not moving; this feature ultimately saves battery life in the field.

Ongoing testing of GPS tracking units is essential for the development of this new technology. It is important for researchers to understand both the capabilities and downfalls of these units, and testing is the best way to find what they are capable of.

3.5.2 *Time-Use Study of Rock climbers in Indian Creek*

In the fall of 2013, a preliminary time-use study of rock climbers in Indian Creek was performed for preliminary testing of the GPS trackers real-world functionality while being carried by rock climbers.

Time-Use Study of Rock climbers in Indian Creek, Utah

Indian Creek is an international destination for rock climbers in Southwest Utah. The management has reported that the number of rock climbers has only been increasing in recent years and expresses concern about the potential of overuse and resource degradation in Indian Creek.

It is important for land managers to understand the spatial and temporal distributions of recreationists to public lands in order to properly manage the resources. Knowing where recreationists are going, how they are getting there, and how much time is spent in those locations allows for further understanding of what resources could be impacted, whether crowding may exist, and whether facilities are adequate.

In the past, collecting temporal and spatial data involved having recreationists draw their paths and record times on blank maps, which is time-consuming and generally unwelcomed while recreating. Now since Global Positioning System (GPS) data collection is available, the task of monitoring spatial and temporal use is easier for the individual in the study and the researcher and can allow for more accurate data collection.

Materials and Methods

Time-use distributions of rock climbers in Indian Creek were collected by distributing Canmore GT-740FL Sport Loggers at the Creek Pasture Campground during a 24-hour period. The units were programmed to collect data at one-second intervals with a minimum logging speed of 0 km/hour. Sampling was conducted from about 7 P.M. November 28 to 7 P.M. November 29, 2013. Participants were selected on the basis that they were rock climbers who would be climbing in Indian Creek the next day and camping in the same place the next evening. Study participants were asked to carry the unit with them at all times for the next 24-hours. They were also informed that the units would be picked up at approximately 7 P.M. the following day. Names and contact information from each participant were collected in order to ensure the return of the unit.

Once GPS units were collected, the data were downloaded to a computer with the use of the Canmore software, exported to CSV, and mapped and analyzed using ArcMaps 10.2 software. Tracks from each participant were clipped coming to and from the campground, to and from the

parking area near the climbing wall, and to and from the climbing wall. This method provided the times at each of these locations in order to analyze the time-used at each location.

Results

Ten rock climbers were asked to carry a GPS unit, and all ten agreed to carry the units for the next 24-hours (100%). Of these participants, 9 climbed the next day (90%). Of the 9 usable tracks, 8 of the GPS units functioned correctly for the entire 24-hour period (89%). The participants were found to have climbed at the following walls: the Second Meat Wall, Broken Tooth, Donnelly Canyon, The Wall, and Battle of the Bulge.

The total amount of time that each participant spent at camp, driving, hiking to the climbing wall, and at the climbing wall was determined from the attribute tables in ArcMaps. These times were then averaged and compared to the length of daylight hours as well as the entire 24-hour period. On the day of the sampling, the total length of daylight was 9 hours and 45 minutes. Of the daylight hours, on average climbers spent 52.3% at the climbing wall, 30% of their time at camp, 6.2% driving, and 11.5% hiking (Table 3). Of the total 24-hour sampling period, climbers spent almost 72% of their time at camp, 21.2% at the climbing wall, almost 5% hiking, and 2.5% driving. For managers of Indian Creek, knowing how much time rock climbers spend in areas throughout the area can provide an understanding of what areas may need the most oversight.

Discussion

Based on the results, the majority of daylight hours are spent at the climbing wall. Since this study took place on a day where the high temperature was 42° F, skies were overcast, and fog had set in, it is probable that a higher percentage of time may have been spent at the climbing wall and less time at camp if more favorable weather conditions had been present the day of the sampling. The amount of daylight may have also contributed to less time spent at the climbing walls. The length of day was 9 hours and 45 minutes on the day of the sampling. In Indian Creek, the shortest day of the year, December 20, is about 9 hours and 30 minutes long. The longest day of the year is June 21 which is about 14 hours and 49 minutes long. Performing this study when daylight hours are longer would likely increase the amount of time spent climbing and decrease the amount of time spent at camp.

The most popular seasons to climb in Indian Creek are early spring and late fall because of the more moderate temperatures. If data were collected during different seasons, temperatures, and day lengths, a more accurate view of how rock climbers were spending their time could be gleaned from

the data. Participants were also all selected from a single campground in Indian Creek. Since climbers camp at three developed campgrounds as well as primitive dispersed campsites, monitoring the temporal and spatial distributions of rock climbers from other camp sites is valuable as well. This study shows the value of GVT in complex recreation settings. Since rock climbers spend the majority of their time at camp and at the base of the climbing wall, managers should focus most of their oversight at camping areas and the base of the cliffs.

Tables

Table 1: Start & Stop for locations throughout the day – start/stop in military time, total in h:m:s.

Unit	Camping			Driving to Climb			Hiking to Climb			At Wall		
	Start	Stop	Total	Start	Stop	Total	Start	Stop	Total	Start	Stop	Total
1	19:00:00	10:24:21	15:24:21	10:24:21	10:45:01	0:20:40	10:45:01	11:41:07	0:56:06	11:41:07	15:21:04	3:39:57
2	19:00:00	10:58:25	15:58:25	10:58:25	11:09:38	0:11:13	11:09:38	11:35:44	0:26:06	11:35:44	17:09:27	5:33:43
3	19:00:00	10:49:26	15:49:26	10:49:26	11:03:42	0:14:16	11:03:42	11:28:42	0:25:00	11:28:42	17:10:16	5:41:34
4	19:00:00	9:22:34	14:22:34	9:22:34	9:36:35	0:14:01	9:36:35	9:54:08	0:17:33	9:54:08	16:57:34	7:03:26
5	19:00:00	10:34:33	15:34:33	10:34:33	11:05:17	0:30:44	11:05:17	13:27:12	2:21:55	13:27:12	16:46:36	3:19:24
7	19:00:00	10:23:41	15:23:41	10:23:41	10:38:29	0:14:48	10:38:29	11:08:25	0:29:56	11:08:25	17:13:52	6:05:27
8	19:00:00	10:21:31	15:21:31	10:21:31	10:34:33	0:13:02	10:34:33	10:59:30	0:24:57	10:59:30	17:23:48	6:24:18
10	19:00:00	10:53:24	15:53:24	10:53:24	11:42:51	0:49:27	11:42:51	12:27:56	0:45:05	12:27:56	15:27:12	2:59:16

Unit	Hiking from Climb			Driving			Camp		
	Start	Stop	Total	Start	Stop	Total	Start	Stop	Total
1	15:21:04	15:38:01	0:16:57	15:38:01	15:50:50	0:12:49	15:50:50	19:00:00	3:09:10
2	17:09:27	17:26:11	0:16:44	17:26:11	17:37:34	0:11:23	17:37:34	19:00:00	1:22:26
3	17:10:16	17:42:09	0:31:53	17:42:09	17:55:05	0:12:56	17:55:05	19:00:00	1:04:55
4	16:57:34	17:15:25	0:17:51	17:15:25	17:30:49	0:15:24	17:30:49	19:00:00	1:29:11
5	16:46:36	17:03:24	0:16:48	17:03:24	17:15:14	0:11:50	17:15:14	19:00:00	1:44:46
7	17:13:52	17:33:57	0:20:05	17:33:57	17:49:23	0:15:26	17:49:23	19:00:00	1:10:37
8	17:23:48	17:43:23	0:19:35	17:43:23	17:57:49	0:14:26	17:57:49	19:00:00	1:02:11
10	15:27:12	15:56:36	0:29:24	15:56:36	16:26:31	0:29:55	16:26:31	19:00:00	2:33:29

Table 2: Total time spent in each activity per unit and combined averages in h:m:s.

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 7	Unit 8	Unit 10	Average
At Camp	18:33:31	17:20:51	16:54:21	15:51:45	17:19:19	16:34:18	16:23:42	18:26:53	17:10:35
Driving	0:33:29	0:22:36	0:27:12	0:29:25	0:42:34	0:30:14	0:27:28	1:19:22	0:36:32
Hiking	1:13:03	0:42:50	0:56:53	0:35:24	2:38:43	0:50:01	0:44:32	1:14:29	1:06:59
At Wall	3:39:57	5:33:43	5:41:34	7:03:26	3:19:24	6:05:27	6:24:18	2:59:16	5:05:53

Table 3: Percentage of time the average climber spends at locations during daylight and total day.

	At Camp	Driving	Hiking	At Wall
% of Daylight	30.0%	6.2%	11.5%	52.3%
% of Total day	71.6%	2.5%	4.7%	21.2%

4 CHAPTER 4: OUTCOMES

4.1 RESPONSE RATE & SAMPLING

From March 10 to April 11, 2014, 161 individuals were asked to participate in this study. Two individuals declined, resulting in 159 participants and yielding a 98.75% response rate. Of the 159 participants, 14 either left the GPS unit at camp or did not climb that day. An additional six of the GPS tracks were found to be invalid due to GPS malfunction. This resulted in an 87% success rate for the GPS tracking.

4.2 QUESTIONNAIRE RESULTS

4.2.1 DEMOGRAPHICS

The figures below summarize the demographic data collected from study participants and include age, gender, race/ethnicity, income, education, and location of residence.

On average, 72.8% percent of the participants reported being male, and 28.2% female. A large majority of participants reported being white (91.1%), followed by Hispanic/Latino (3.2%), Asian (1.3%), American Indian (1.3%) and African American, Pacific Islander, and multi-racial (0.6% each). The leading household income bracket among participants was less than $24,999 (44.9%), followed by $35,000 to $49,999 (15.2%), $25,000 to $34,999 and $50,000 to $74,999 (11.4% each), $75,000 to $99,999 (8.2%), $100,000 to $149,999 (3.8%), and over $150,000 (1.9%). Participants reported having a high level of education, with 50% being four-year college graduates, 25.9% had graduate degrees, 15.2% had completed some college, 6.3% completed a 2-year degree, and 2.5% had either a full or partial high school education. The average age of study participants was 30.1 years old, with 60 years being the maximum and 20 years the minimum. Fifty percent of participants were younger than 29 years old, 75% of participants were younger than 35 years old, and almost 90% of participants were younger than 40 years old. Twenty-six states and nine countries were represented in this sample population. Of those participants located in the United States, a large majority reported living in Colorado (28%), followed by California (11.5%), Montana (7.6%), and Utah (6.4%). The countries represented include the United States (86%), Canada (8.9%), Norway (1.3%), and Australia, Denmark, Germany, Mexico, Spain, and Switzerland (0.6% each).

Figure 4a: Location of study participants' zip codes in the United States

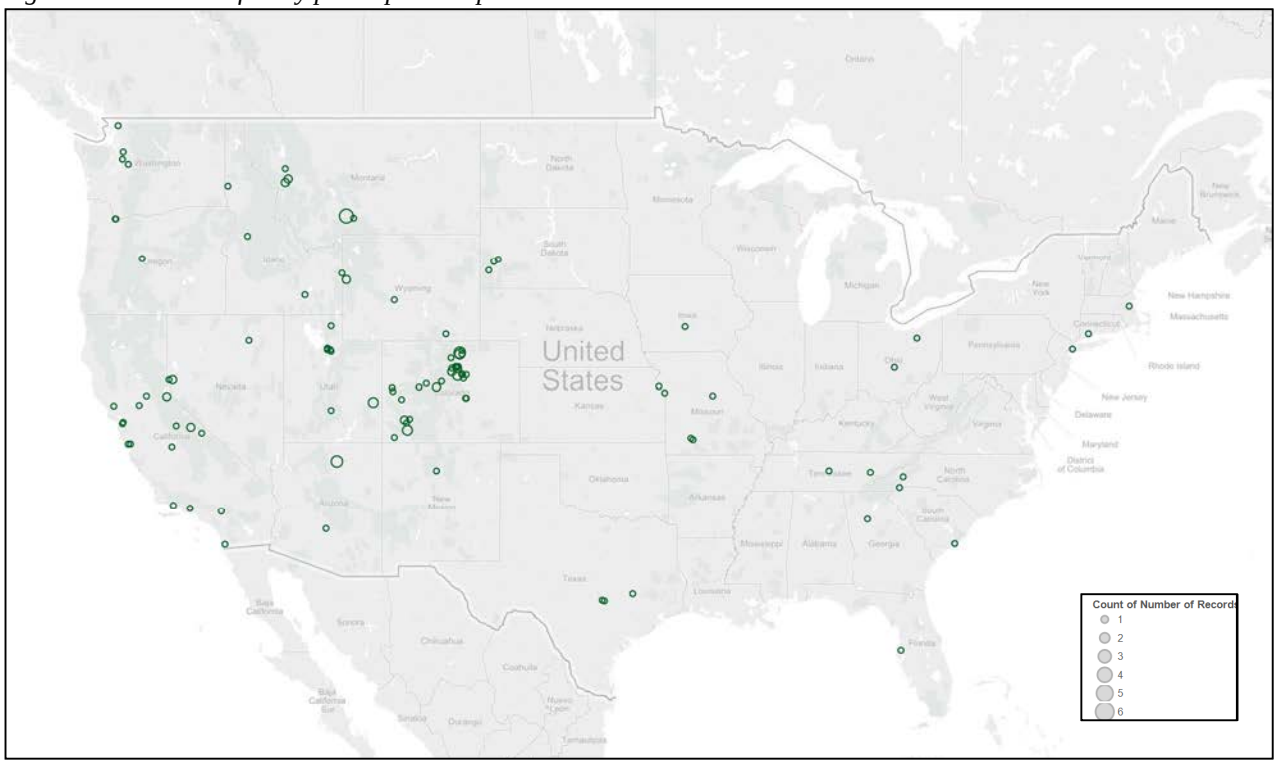


Figure 4b: Number of study participants from different countries

Figure 4c: Gender of study participants

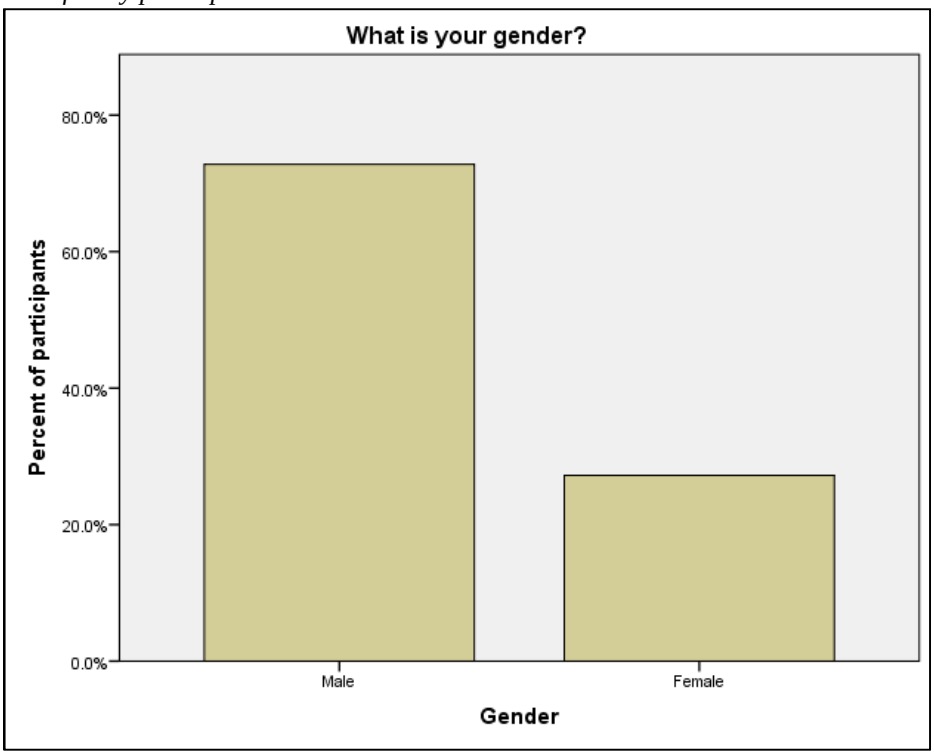


Figure 4d: Age of study participants

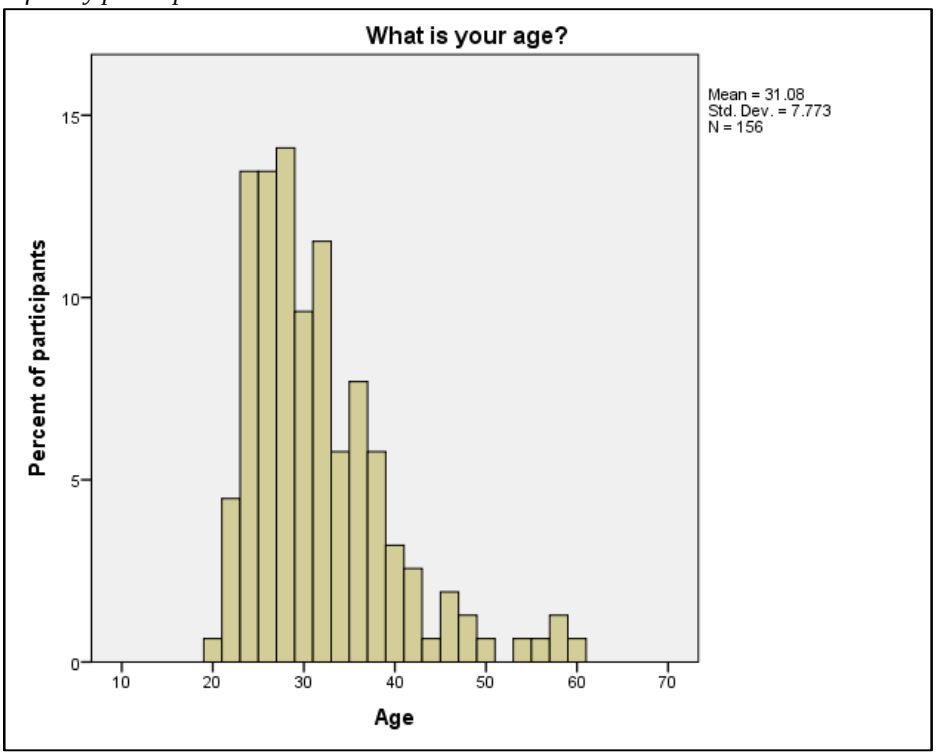


Figure 4e: Highest level of schooling completed by study participants

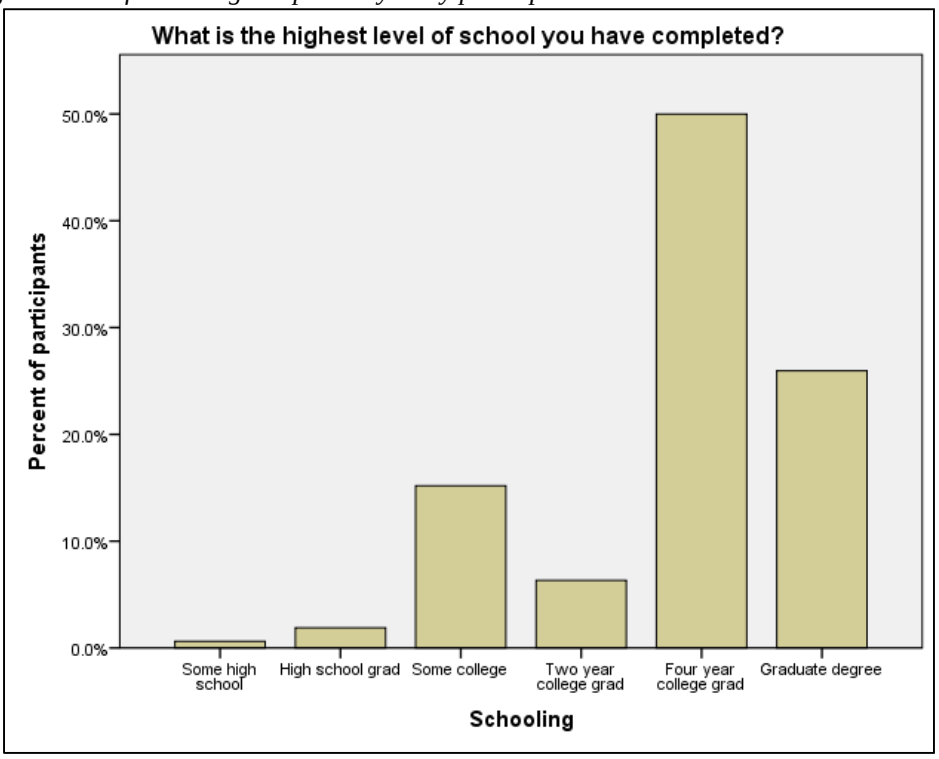


Figure 4f: Race/ethnicity of study participants

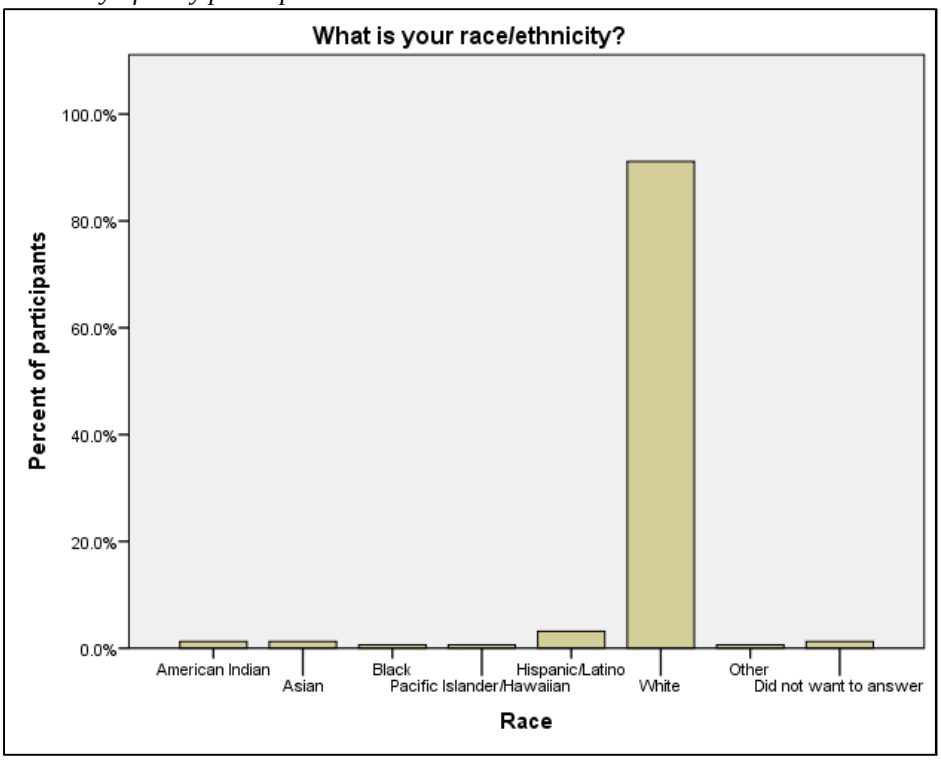
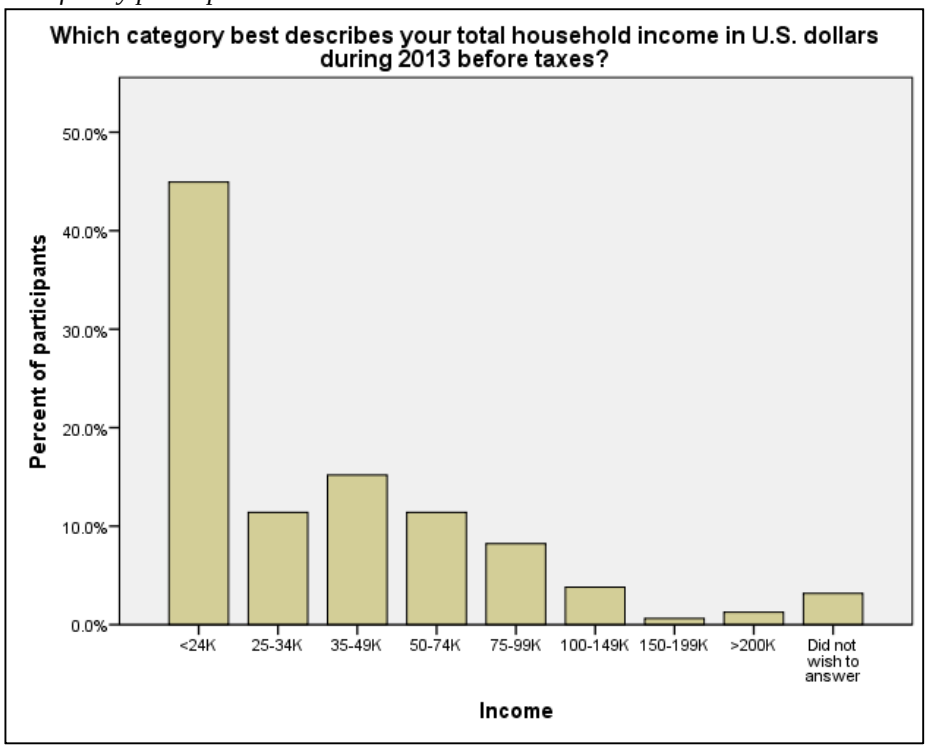


Figure 4g: Income of study participants



4.2.2 PAST USE HISTORY

For rock climbers in Indian Creek, the average number of days climbing in the last year was almost 118 days, with the most participants responding that they climb about twice a week. Yet, there was a relatively large range on number of days reported (S.D. = 74).

On average, participants climbed approximately 13 days a season in Indian Creek, with 10 days being the most reported. Again, there was a large range on the number of days climbing in Indian Creek each year (S.D. = 14). The average amount of years spent climbing in Indian Creek was approximately 4.5 years (S.D. = 4.5), while the most common response was one year.

Figure 4h: Days of climbing per year

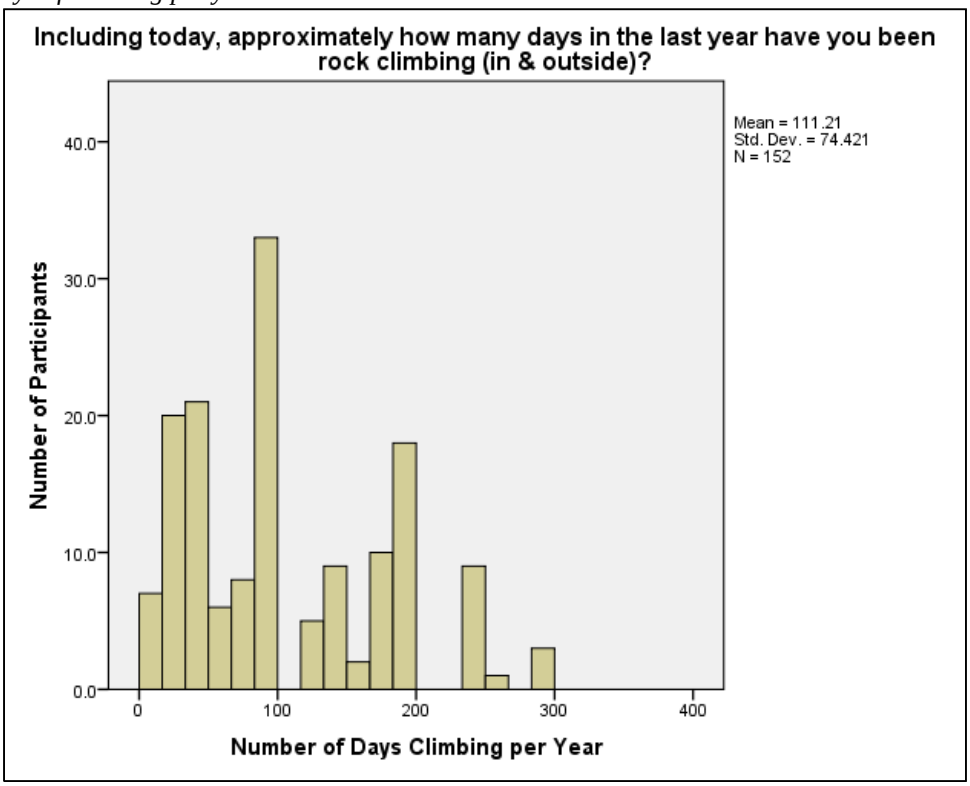


Figure 4i: Days climbing in Indian Creek in the last year

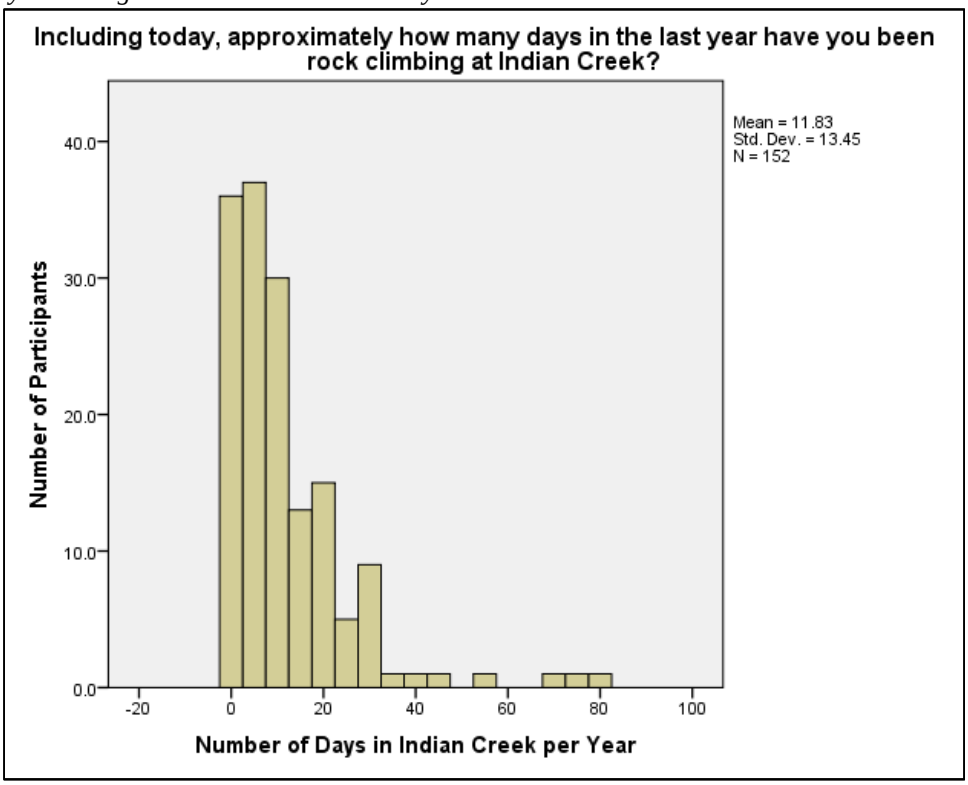


Figure 4j: Years climbing in Indian Creek

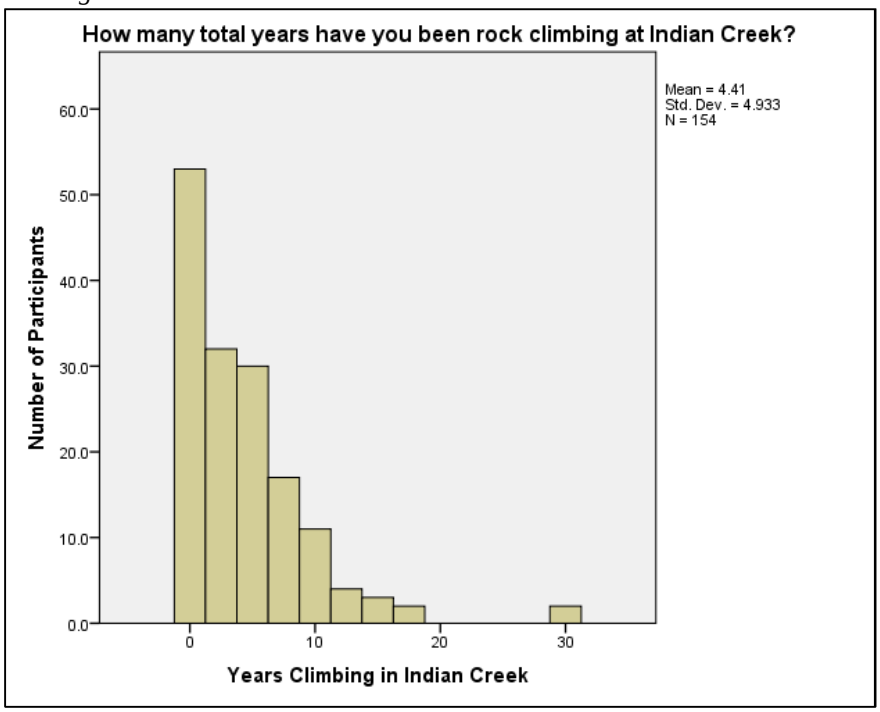


Table 4a: Self-reported past-use history for the study participants

	M (S.D.)	Mode	Median
Including today, approximately how many days in the last year have you been rock climbing (in & outside)?	117.8 (73.8)	100	100
Including today, approximately how many days in the last year have you been rock climbing at Indian Creek?	12.6 (13.7)	10	9
How many total years have you been rock climbing at Indian Creek?	4.6 (4.55)	1	3

4.2.3 SPECIALIZATION

Table 4b demonstrates that the majority of climbers in Indian Creek consider themselves to be highly specialized at rock climbing based on the mean scores for each narrative. Specialization is a process that exists on a continuum, and as an individual's specialization in an activity increases, so will a variety of behaviors and preferences linked to time dedicated to the activity, money spent, setting, and technique (Manning, 2011). The highest ranked narrative with a mean of 7.34 describes the preferences and behaviors of a highly specialized individual who dedicates a high amount of time and money to their primary activity, is highly skilled, and dedicates time to learning

more about their activity. Regarding this sample, 33% of the participants indicated that this narrative strongly describes them, with another 46% also strongly identifying with this narrative.

The second highest ranked narrative had a mean score of 3.85, and describes an individual with a moderate level of specialization. Almost 20% of participants indicated that this narrative did not describe them at all, with another 29% listing a low level of identification with this narrative. The lowest ranked narrative had a mean score of 1.77, and describes an individual with low specialization. The mean score for this narrative suggests that most participants did not identify with this narrative, and this is supported by the 59% of respondents who replied that this narrative does not describe them at all. Taken together, the results from these narratives characterize Indian Creek rock climbers as being highly specialized in rock climbing.

Table 4b: Participant responses to questions on specialization

Narrative	Not at all like me (1)		% of response					A lot like me (9)		Mean (S. D.)
Low Specialization Narrative Rock climbing is an enjoyable, but infrequent activity that is secondary to other travel and outdoor interests. I am not highly skilled, rarely read articles about climbing and do not own much equipment beyond the basic necessities.	58.9	23.4	11.4	1.9	1.3	0.0	2.5	0.0	0.6	1.77 (1.34)
Moderate Specialization Narrative Rock climbing for me is important, but I do other outdoor activities too. I occasionally read articles about climbing & purchase equipment for climbing. My participation in rock climbing is inconsistent and I am moderately skilled.	19.6	8.2	20.9	14.6	14.6	9.5	5.7	3.8	3.2	3.85 (2.18)
High Specialization Narrative Rock climbing is my primary outdoor activity. I purchase increasing amounts of equipment for rock climbing, participate in rock climbing every chance I get, consider myself highly skilled in climbing, and frequently read about climbing.	3.2	1.9	1.3	1.3	5.7	8.2	20.9	24.7	32.9	7.34 (1.93)

4.2.4 *SELF-REPORTED SKILL LEVEL*

Table 4c suggests that rock climbers in Indian Creek have an intermediate to moderately high level of skill based on the mean score of 6.2. Twenty-six percent of the participants indicated a relatively high level of skill, with another 48% specifying an intermediate to moderately high level of skill. These results coincide with the reported high level of specialization found in Table 4b and provide some validity for the findings in Table 4b.

These results also correspond with participant responses to what grade they lead climb or if they only top-rope climb. Top-rope climbing occurs when a climber attaches himself to one end of a rope, which then passes up through an anchor at the top of the wall, and then down to a partner who belays the climber. As the climber ascends the wall the belayer pulls in the slack rope; so that if a climber were to let go, he would be held in place on the wall. Top-roping is psychologically easier and less physically demanding than lead climbing. The climbing grade for routes is a ranking system for how difficult a climb is with 5.0 being extremely easy and 5.14 being extremely difficult. On the other hand, a climber will 'lead climb' by attaching himself to one end of a rope and climbing the wall while periodically attaching his rope to fixed protection along the route. This does give potential for larger falls and presents a greater mental challenge. Generally a climber will have climbed many times on top-rope before he progresses to lead climbing.

All climbing in Indian Creek is very difficult, since it is rare to find a climb rated 5.9 or below (moderately difficult), most routes are graded at 5.10 and 5.11, and climbing on the parallel cracks of Wingate sandstone requires a particular skill set. That being said, 90% percent of study participants reported to lead climbs in Indian Creek. 5.8% only led climbs in Indian Creek that were the easiest option in the area (5.9). 36% led climbs graded at 5.10, 37% led 5.11s, and 10% led 5.12s.

Table 4c: Participant responses to questions on self-reported skill level

	Beginner (1)		% of response					Advanced (9)		Mean (S. D.)
Please indicate your rock climbing skill level.	0.0	1.9	1.9	3.8	22.8	24.7	25.9	13.3	4.4	6.21 (1.4)

Figure 4k: Participant responses to typical lead grade (‘10’ equals a grade of ‘5.10’)

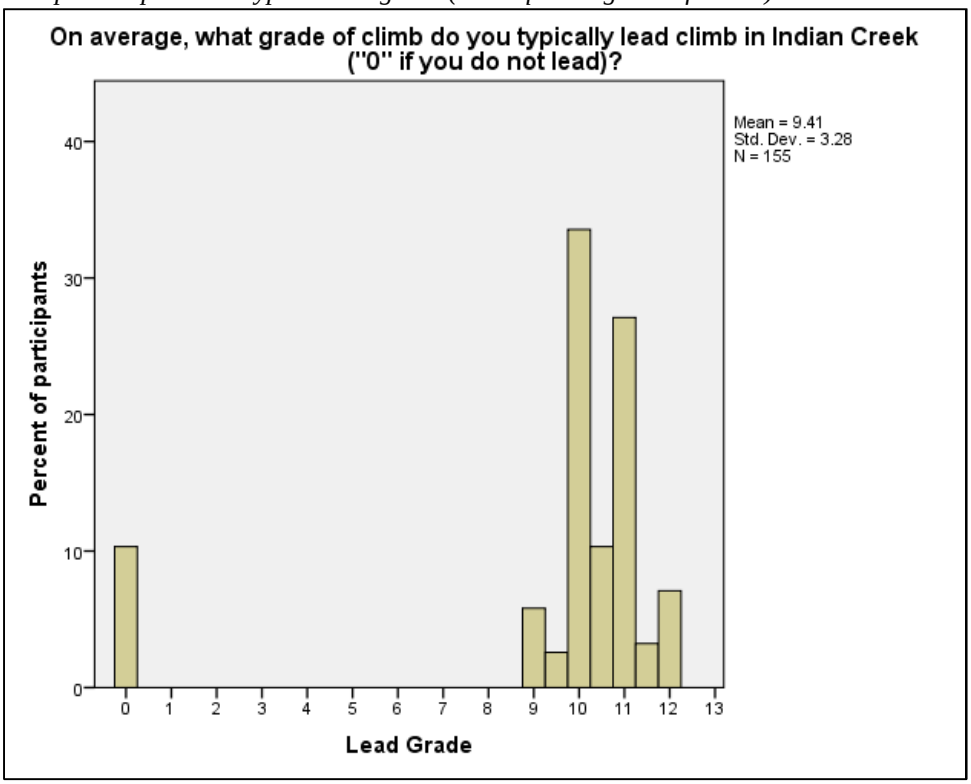
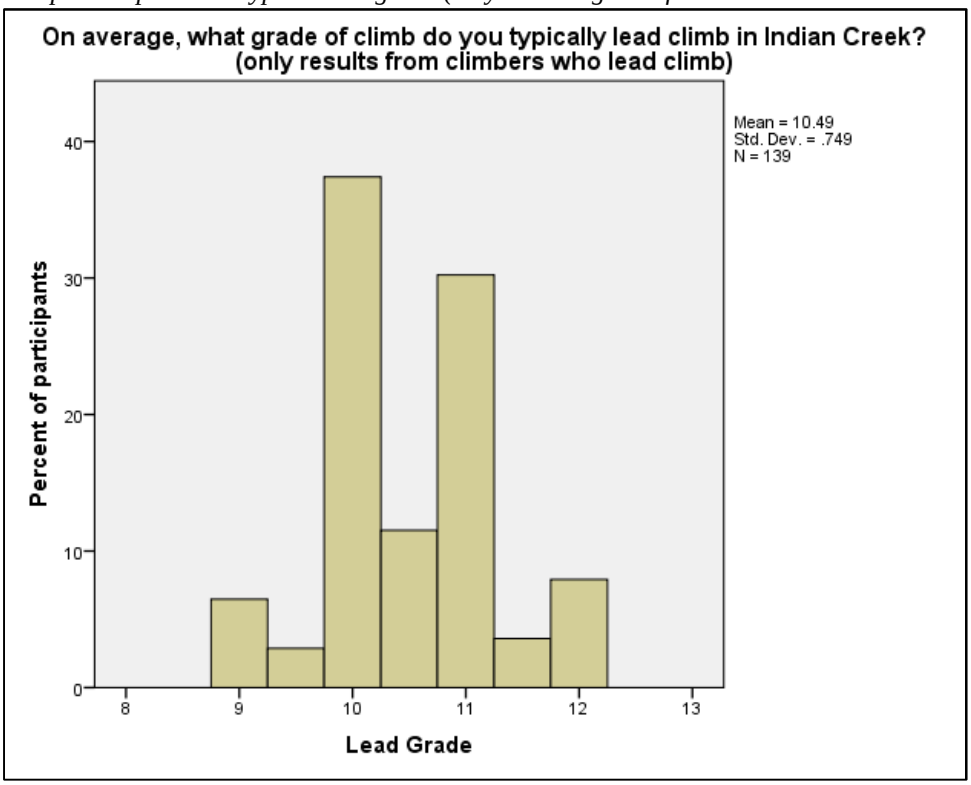


Figure 4l: Participant responses to typical lead grade (only including data from climbers who lead climb)



4.3 GPS Visitor Tracking Results and Discussion

4.3.1 Component 1: Time-Use Study Results & Discussion

The sampled population of climbers in Indian Creek was found to be homogenous in perceived skill level, experience use history, specialization, and demographics. Therefore, finding a 'type' of climber who may spend more time at any one location throughout the day was not possible.

Results indicate that although climbers spend time at each location (camp, driving, parking lot, trails, and wall), all climbers sampled spent over half of their time at camp and averaged about a quarter of their time at a climbing wall during a 24-hour period. The average climber left camp at 10:41 AM and spent half of their daylight hours at a climbing wall. Lastly, the average climber spends more time driving than they do hiking or in parking lots.

The sampled population of climbers in Indian Creek was found to be homogenous in perceived skill level, experience use history, specialization, and demographics. Therefore, finding a 'type' of climber who may spend more time at any one location throughout the day was not possible.

While it seems obvious that most time would be spent at camp and at the climbing wall in Indian Creek, it was less expected to find the driving time was higher than hiking time.

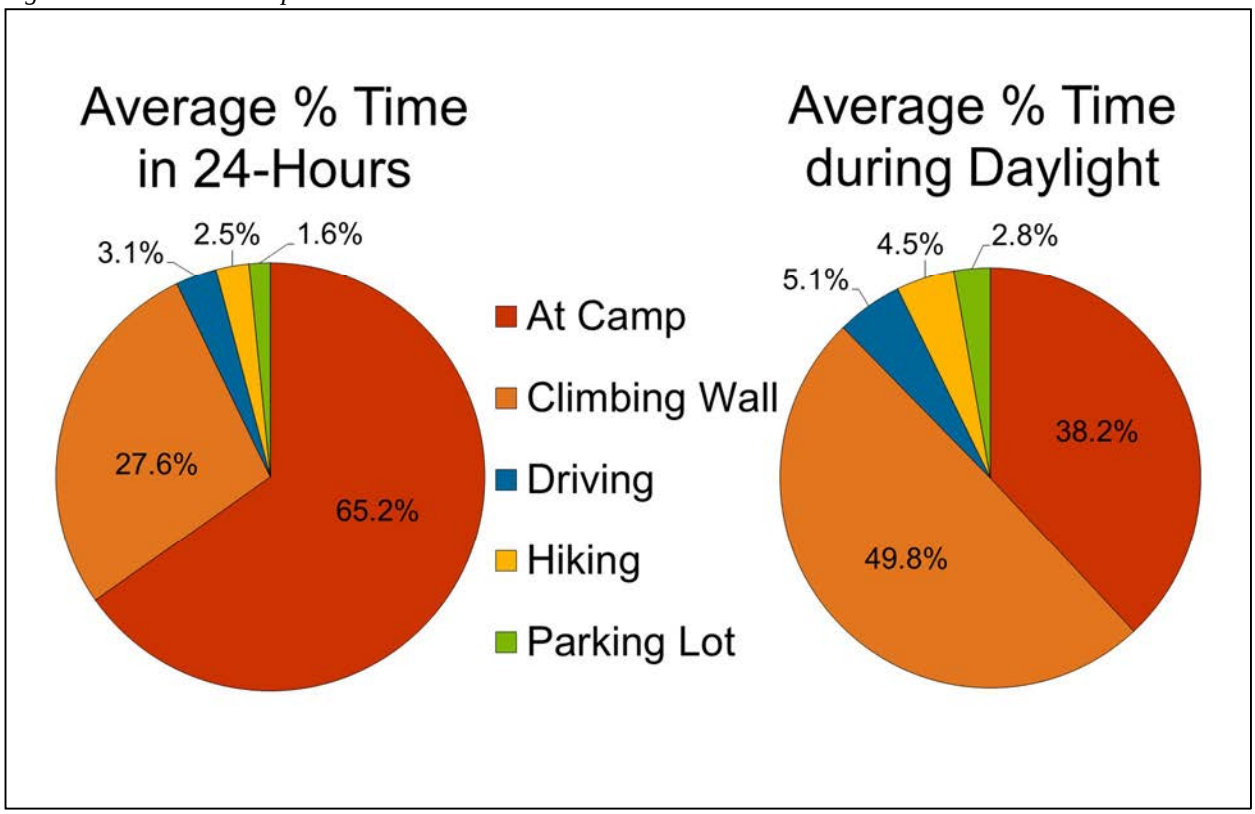
Table 4c: GVT Results – Percent time in 24-hour period

Percent of Time Spent in Indian Creek in a 24-hour Period				
	Mean	Minimum	Maximum	SD
At Camp	65.2%	52.0%	93.8%	7%
At Climbing Wall	27.6%	0.1%	41.6%	7%
Driving	3.1%	0.4%	12.4%	2%
Hiking	2.5%	0.5%	25.8%	3%
In Parking Lot	1.6%	0.2%	7.5%	1%

Table 4d: GVT Results – Percent time during daylight hours

Percent of Time Spent in Indian Creek during Daylight Hours				
	Mean	Minimum	Maximum	SD
At Climbing Wall	49.8%	0.3%	78.2%	14%
At Camp	38.2%	16.2%	88.6%	12%
Driving	5.1%	0.7%	22.5%	4%
Hiking	4.5%	0.1%	44.3%	5%
In Parking Lot	2.8%	0.4%	12.1%	2%

Figure 4m: Percent time spent in Indian Creek



4.3.2 *Component 2: Informal Trail Use Results & Discussion*

This component was meant to compare trail locations and questionnaire data in order to characterize the type of climber that may be contributing to informal trails as well as provide answers to the questions 'Which rock climbers contribute to informal trails?' and 'Do different rock climber types travel in different ways?'. However, the sampled population of climbers was found to be homogenous in perceived skill level, experience use history, specialization, and demographics. Therefore, finding a 'type' of climber who may be contributing most to informal trails was not possible.

Nevertheless, the GPS Visitor Tracking did shed light on user confusion on what roads to take to get to climbing areas, where climbing walls were located, and where the trail is located. This should be no surprise, since the Indian Creek landscape is a sea of red rock and sand (Figure 4n), and climbers are often faced with relying on vague directions and images of a rock face from guidebooks to make it to their desired location. Climbers get accustomed to 'climbers' trails,' which are steep, crumbly trails put in by other climbers over time. These climbers can be conditioned over time to 'follow the footprints', which ultimately can lead to social trail development. Cairns, piles of rocks set as trail markers, are often meant to guide a climber to the climbing wall; however, if a climber is ten feet

from the trail, the actual trail is often difficult to find. Cairns are a great way for the initial trail blazers to show the next group where the trail or best route is. However, after many years of climbers placing cairns where they believe the best trail location is, cairns tend to start littering the landscape, which ultimately only confuses those attempting to find the best path.

Figure 4n: Examples of trails in Indian Creek

4.4 TRAIL MAPPING RESULTS

The trails to 54 climbing areas in Indian Creek were hiked by researchers carrying a Trimble Juno GPS unit. A map of these current trail locations can be found in Appendix B. The quality of the trail access to these climbing areas ranged from hardened surfaces that were easy to find to absolutely no trail at all. Many trails were found to be so braided from social trails near the climbing wall that it was difficult to find the 'real' trail. Many areas also have multiple trails to access the same wall. It must be noted, however, that historically these climbers' trails were started and developed by the recreationists using the area. Very few of these trails have been planned out and developed by trail crews over the years. That being said, several climbing areas have trails that, over the years, have been redesigned and developed by qualified personnel. Appendix F contains a table with a brief description of each trail's quality and access.

Trails to climbing areas are listed below and categorized as follows:

Condition	Comments
Excellent (Bold green)	Easy to find and follow. Hardened and modified trail. Clear of fallen debris or loose rock.
Good (Green)	Relatively easy to find and follow. Can have sections of modified trail. Encountering fallen debris is possible.
Partially Good (Blue)	Relatively easy to find and follow in some sections, but difficult in others. Some sections of this trail are steep and loose, while others are well traveled and have been modified. Encountering fallen debris is likely.
Poor (Orange)	Difficult to find and follow. Steep and loose trail with bushwhacking sometimes necessary. No modification or hardening. Encountering fallen debris is certain.
Cairns Only (Red)	No trail could be found but widely spaced cairns were located and could be followed to the climbing area. Extremely loose and full of fallen debris.
No Trail (BOLD Red)	No trail could be found

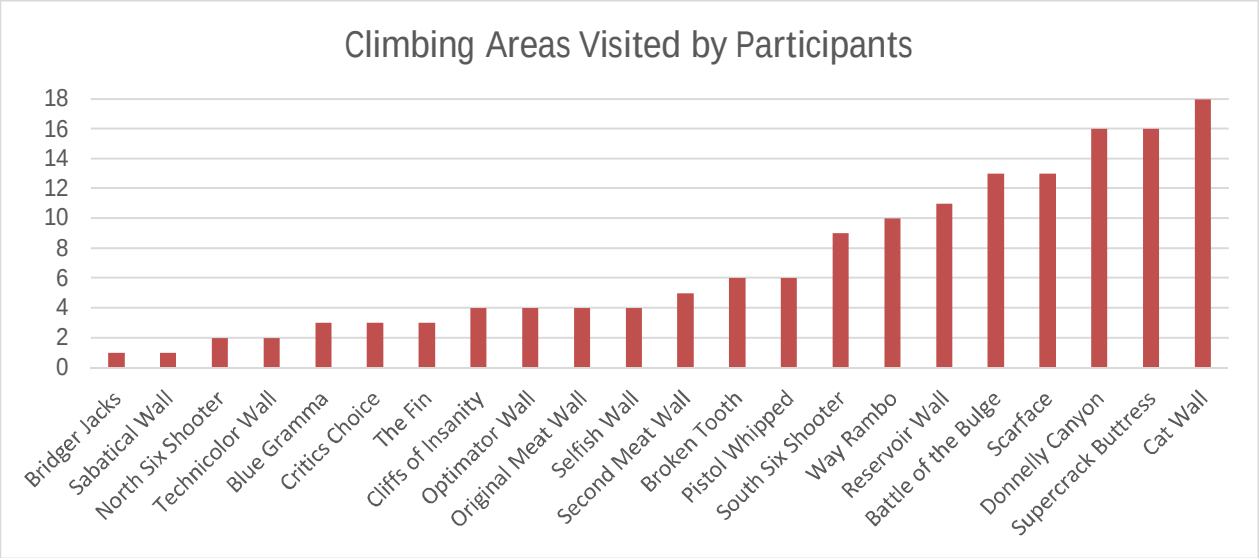
1st Meat Wall
2nd Meat Wall
4 x 4 Wall
75 Cairns
Altitude Wall
The Back Wall
Battle of the Bulge Buttress
Bioturbation Wall
Blue Gramma Cliff
The Bridger Jacks
Broken Tooth
Cactus Flower Buttress
Cat Wall
Cliffs of Insanity
Critic's Choice
Disappointment Cliffs
Donnelly Canyon
Election Wall
Fin Wall
Friction Slab
Fringe of Death Canyon
Fringe of Life Canyon
The Gash
Love Wall
New Wave Wall
North Six Shooter Peak
The Optimator
The Original Meat Wall
Over the Hill
Petrified Hornet Wall
Pistol Whipped
Pods Wall
Power Wall
Public Service Wall
Reservoir Wall
Sacred Cow
Sabbatical Wall
Scarface
Scorpion Corner
Selfish Wall
Shock and Awe
Sinbad Wall
Six Star Wall
Slug Wall
South Six Shooter Peak
Sparks Wall
Suburbia
Supercrack Buttress
Technicolor Wall
Tenderloins
Tricks Wall
Vitamin **D** Wall
The Wall
Way Rambo

4.5 Participant Trail Use

Of the 54 climbing areas listed, study participants were found to have traveled to 22. Figures 4n and 4o represent the number of study participants who visited each climbing area. The GPS tracks of participants can be seen in Appendix C. The top ten climbing areas visited by study participants were:

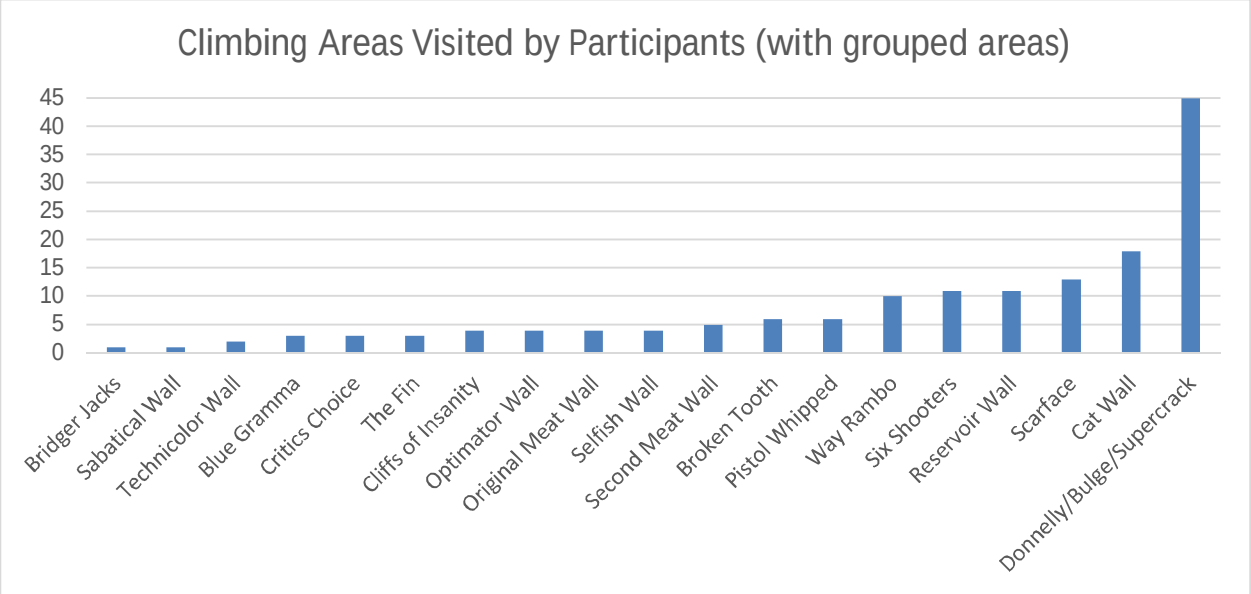
1. Cat Wall
2. Supercrack Buttress
3. Donnelly Canyon
4. Scarface Wall
5. Battle of the Bulge
6. Reservoir Wall
7. Way Rambo
8. South Six Shooter
9. Pistol Whipped
10. Broken Tooth

Figure 4n: Number of study participants to visit each climbing area



Since Supercrack Buttress, Battle of the Bulge, and Donnelly Canyon areas are all accessed within a five minute hike from the same parking lot, these areas have been grouped as part of this report. The North and South Six Shooters also exhibit similar qualities in that they are towers that require a high clearance vehicle and long hike, so these two areas were also grouped.

Figure 4o: Number of study participants to visit each climbing area (combining Donnelly Canyon, Battle of the Bulge, and Supercrack areas and Six Shooter areas)



After these areas were grouped, the top six visited areas were:

1. Supercrack/Battle of the Bulge/Donnelly Canyon areas
2. Cat Wall
3. Scarface Wall (no signage recommendations)
4. Reservoir Wall
5. The Six Shooters
6. Way Rambo

After visually assessing maps that overlay the current trail locations and GVT, signage recommendations were made.

4.6 Signage Recommendations for the Most Visited Climbing Areas

After overlaying maps of Indian Creek with the current trail locations and GVT data, the researchers were able to visually assess where study participants were deviating from trails.

Appendix E contains recommendations for descriptive signs and arrows at the top five visited climbing – Supercrack/Battle of the Bulge/Donnelly Canyon, Cat Wall, Reservoir Wall, The Six Shooters, and Way Rambo. Recommendations were not made for the Scarface Wall since the trail to Scarface is in good condition. Recommendations for each climbing area consist of a map showing the current trail location from parking area to climbing wall, the GPS Visitor tracks. Numbers coincide with the document following the map with the recommended verbiage for the narrative signage.

Supercrack Buttress, Battle of the Bulge Buttress, and Donnelly Canyon are all accessed from a single large parking lot and all three walls are within a five minute hike from the parking lot with restroom facilities. These areas make up one of the first cliffs seen as climbers and tourists drive down Highway 211 into Indian Creek. Each wall also has many easier routes in the 5.10 range as well as many 'classic' routes. These reasons combined make this area heavy with traffic from rock climbers and tourists traveling to the Needles District of Canyonlands and want an up close view of rock climbers. While it is obvious that much work has gone into this area and the trails it contains, the heavy traffic has quickly run some of the trails down. Looking at the map of this area in Appendix E, the Battle of the Bulge Buttress and Supercrack Buttress both have easy to follow trails that lead to the climbing wall. However, the two trails to access Donnelly Canyon appear difficult for climbers to follow. These GPS tracks from study participants match with the researcher's description of these trails in Appendix F.

The Cat Wall is accessed about a minute down a dirt road off of Highway 211. Since there is very little shade at this wall during the day, the Cat Wall is an ideal location to climb at when it is cold and clear. According to Indian Creek: A Climbing Guide by David Bloom (2013), this wall also boasts the most climbs per square foot than any other climbing area in Indian Creek. As seen in Appendix E, the Cat Wall has two access trails, one to the north and one to the south. The trail to the south is easier to find, more hardened, and less loose than the trail to the north, and while the guidebook maps say not to park at the base of the south trail, there is no signage in the area that confirm no parking in this area. The north trail to the Cat Wall gets more traffic and is mostly in good condition. However, as seen on the maps, the trail is easily followed up to the wall, but many GVT participants found the trail confusing in several key locations. These confusing trail sections could be made more easily followed with a little trail maintenance and arrow signs.

Reservoir Wall is easily accessed by parking on the side of Highway 211. This climbing area wraps around a buttress, which gives climbers access to both sun and shade throughout the day. Two trails exist that access this wall. As seen in Appendix E, the trail to the south crosses private land. This steep trail winds its way up a gully full of talus that is very loose. The researcher gave up on trying to follow this trail because so many rock sloughs covered it in so many sections. The trail to the north is in great condition with only a couple loose sections. It is recommended that trail closure signage be placed at both ends of the south trail to mitigate conflict between private land owners and for the safety of those accessing this wall.

The North and South Six Shooters are the two classic desert towers in Indian Creek. While both of these towers require route-finding skills, either a very long walk or a high clearance vehicle, a hefty uphill hike, and the knowledge to climb routes with multiple pitches, the icon status of these towers draws a larger number of visitors than one would expect. Since the towers are located on crumbling talus slopes, even the best trails get covered in debris and can be hard to find in spots.

As seen in Appendix E, the North Six Shooter is either accessed from the north or south. The south is the well-marked trail and is accessed by taking Davis Canyon Road and then following washes that lead just to the south of the North Six Shooter. In the past, this may have been the most common way to access the North Six Shooter, however, all participants who climbed at the North Six Shooter used the northern access point. Accessing the North Six Shooter from the north is not easy, since there are no trails from this direction, only extremely widely spaced cairns and very short sections of footprints to follow. Using this northern access may be appealing since it is easier to access without a high clearance vehicle.

As seen in Appendix E, the South Six Shooter has many trails that lead to it, but access from the south is the most common and has the best trails. However, many choose to access the South Six Shooter from the north of it via the same washes one would access the trails to the North Six Shooter. The trail from this direction is not very good and is difficult to follow. The shortest trail to access the South Six Shooter is also the longest drive – one must drive all the way around to the east of this tower in order to access this very good trail. The remaining two marked trails are relatively easy to follow but require a longer hike. In general, the entire slope leading to this tower is riddled with cairns. While cairns were built to help those trying to find their way, too many cause confusion in this area.

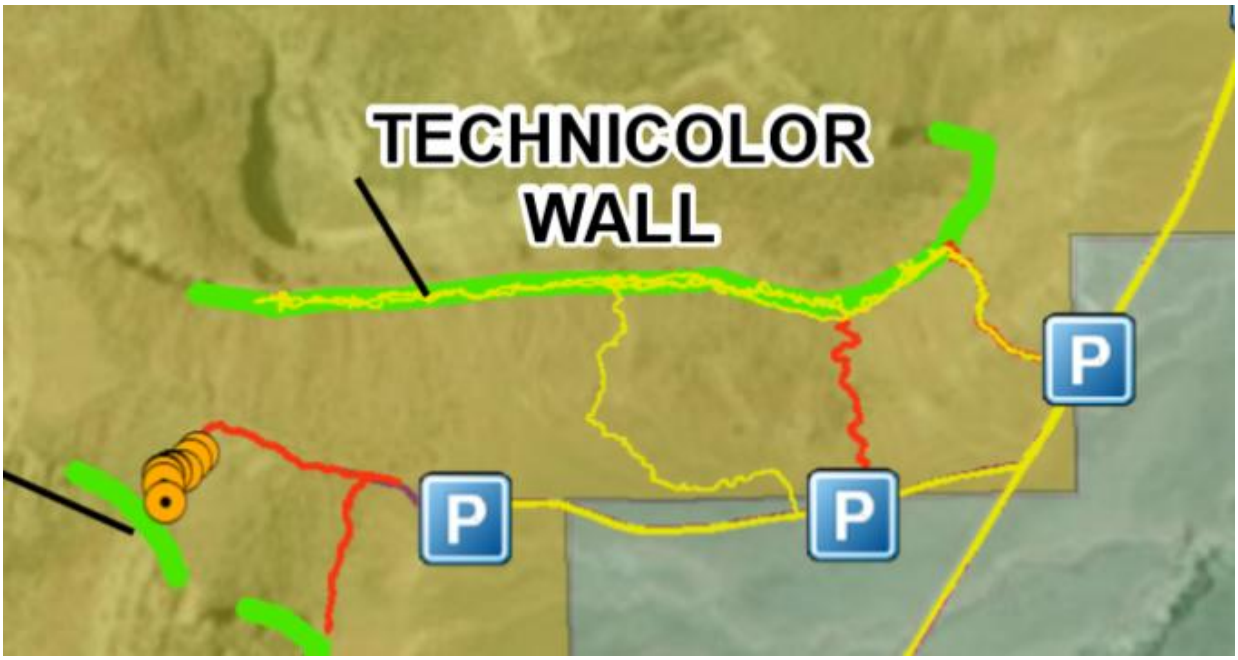
Access to Way Rambo requires climbers to drive down Beef Basin Road off of Highway 211 and cross a creek twice. This area is popular due to a large number of moderate routes. It is obvious that trail work has been done in this area in the past, however, the trail has degraded over time. While the majority of this trail is easy to find, it becomes more braided and confusing about halfway up the slope. Directional signage and a little bit of trail maintenance should direct climbers easily.

4.7 Interpretation of GPS Visitor Tracking

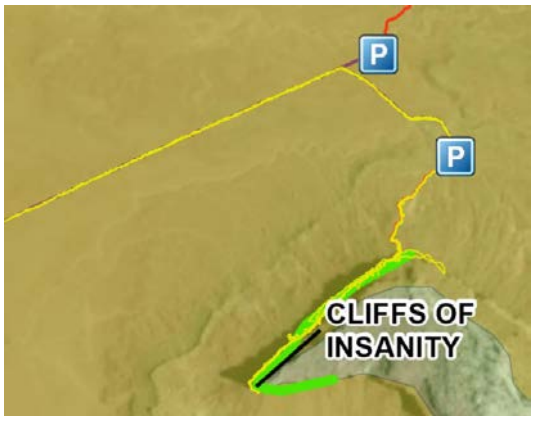
Appendix C contains the maps of GPS Visitor Tracks (in yellow) that overlay the current climber trail locations (in red). By observing where the yellow lines deviate from red lines, one can determine where climbers are getting confused on roads and on trails. Pairing this information

with notes on trail access and quality, recommendations can be made on possible trail closures and subsequent restoration. As stated earlier in this report, the Reservoir Wall is a good candidate for trail closure to one of the two trails. Another example is the Technicolor Wall. Two trails were mapped, one was very poor quality and the other was very good. However, the guidebook guides climbers to use the poor quality trail located on Beef Basin Road, as seen in Figure 4p on the right. Of the several study participants to climb at Technicolor Wall, none of them used the good trail in the middle of the wall, and the GVT just to the left was not a trail location at all.

Figure 4p: Example of deviations of GVT (in yellow) from actual trail locations(in red)



As seen below, GVT shows that participants who traveled on trails listed in 'excellent condition', such as to The Cliffs of Insanity, tended to stay on the correct trail more often than those on trails in 'poor condition', such as the Sabbatical Wall.



Appendix D contains recommendations for narrative signage placements on roadways to direct climbers to climbing areas. Signage with names of the climbing walls is recommended at every turn off from the main highway and road. This will lessen confusion of drivers and lead to less traffic on these roads.

4.8 RECOMMENDATIONS FOR FUTURE RESEARCH

This study took place over four and a half weeks. A larger study group and longer sampling period could possibly yield statistically significant differences within the study population. This study also coincided with college spring break, which may have influenced the resulting study population. The entire sampling period did not have much variability in weather data, such as temperature, daylight hours, cloud cover, and precipitation. By repeating this study during different times of the year, future researchers may expose the importance of weather to climbing area preference. Since several trails were recommended for closure and subsequent restoration, repeating GVT in areas with trail closures would give management an idea if closure signage did actually force climbers to the alternate trail. Furthermore, since signage recommendations for trails were only made for 5 of the 54 climbing areas, signage recommendations could subsequently be made for trails to the remaining 49 climbing walls.

With the data that was collected during this study, however, there is certainly more information to be gleaned. The ArcMaps software is rich with options to pull apart GIS data. Density analyses can be run to see which areas are used more than others. The Z axis from the GVT tracks can be input in order to see vertical data in 3D. The 'Standard Distance' tool can be used to calculate distance of each participant's travel from their campsite. Weighted spatial statistics in ArcMaps can also be used to find out if features having similar values occur together, for example, climbing areas with similarly high or low climber access form clusters. In this study, these weighted spatial statistics can be used to show visual representation of how popular a climbing area was by representing it with a larger circle on the map.

In addition, the same research could be performed at other large climbing areas such as Joshua Tree in California, Red Rocks in Nevada, the Wind River Range in Wyoming, and Yosemite National Park in California. If studies in different climbing areas were performed with the same methods, the results from different locations could be compared to each other in order to find common variables within the climbing population. Uncovering common variables within the countries climbing population could lead to the development of collective management strategies at multiple climbing areas.

4.9 IMPLICATIONS

It is important for land managers to understand the spatial and temporal distributions of visitors because knowing where visitors are going, how they are getting there, and how much time is spent in those locations allows for further understanding of what resources could be impacted, whether crowding may exist, and whether facilities are adequate (Beeco and Brown, 2013). Especially in complex recreation settings, the use of GPS trackers is an ideal way to obtain accurate and precise data with units that are easy to use and easy for participants to carry.

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Appendix A:

Manual: GPS Tracking of Rock Climbers in Indian Creek, Utah

University of Utah: Parks, Recreation & Tourism Department

Manual: GPS Tracking of Rock Climbers in Indian Creek, Utah

Kathryn DeSirant White
2/27/2014

UNIVERSITY OF UTAH: PARKS, RECREATION & TOURISM

MANUAL: GPS TRACKING OF ROCK CLIMBERS IN INDIAN CREEK, UTAH

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TABLE OF CONTENTS:

1 INTRODUCTION

This manual is meant to inform personnel involved in the GPS tracking of rock climbers in Indian Creek on the GPS units and the data collection, downloading, and data manipulation processes.

2 CANMORE GT-740FL SPORT GPS DATA LOGGER

Each of the twenty data loggers is labeled by number 1-20.

2.1 CANMORE SOFTWARE – "CANWAY"

The Canmore Logger comes with a mini-CD that contains instructions and software necessary to downloading data from the GPS logger. The CanWay software allows for the modification of the GPS logger settings.

2.1.1 CANWAY INSTALLATION

1. Download the Canmore Logger CD and save all files to computer.
2. In the "GPS Logger software" folder, you will find the installation software "CanWay Installer_1.1.03" and the instructions for the Canmore Logger, "CanWay_user manual_EN_1.0".
3. Double Click on and install the "CanWay Installer_1.1.03" installation software. When the "Select Additional Tasks" tab appears, check the box next to "Install USB driver." A desktop icon can also be created at this time.
4. If any problems occur, the user manual contains more detailed steps for installing CanWay.

2.1.2 GETTING STARTED WITH CANWAY

1. Open CanWay.
2. The program will ask for personal information about the user (this may be left blank).
3. Make sure the "Unit of Measurement" is set to Metric
4. Make sure the "Show latitude/longitude" is set to Decimal Degrees (this will allow for easier manipulation in ArcMaps).
5. "Height/weight" and "Activity Groups" do not need to be filled out.
6. Finish and exit the setup wizard.

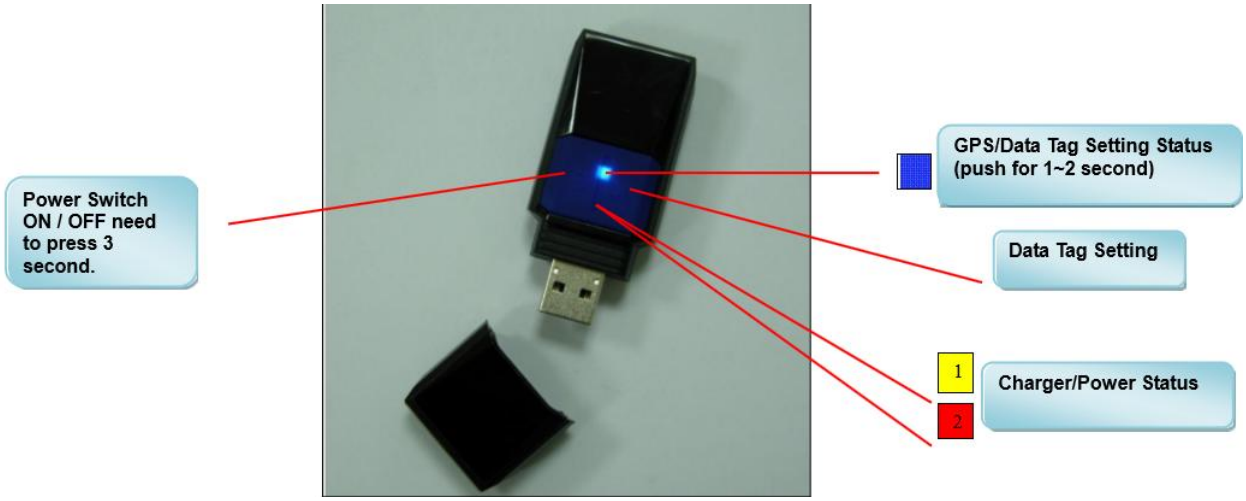
2.2 GENERAL INFORMATION ON THE GT-740FL

- The user manual for the GT-740FL logger can be found on the Canmore Logger CD in the "GT-740FL_Sport LogBook" folder to access.
- Before connecting the GT-740FL, download the USB driver that is specific to the GT-740FL. It is located on the CD, in the folder marked "GPS USB Dongle Driver" and named "VCP_V1.3.1_Setup_x64"

- Charging the battery – remove the USB cover and plug into a USB port on a computer or an AC adapter. When charging, the Yellow LED will be lit. When fully charged, the Yellow LED will be of. The battery takes about 2 hours to fully re-charge.

2.2.1 LED DISPLAY & BASIC OPERATIONS

	Yellow LED = battery is charging
	Red LED flashing 1 sec. ON/1 sec. OFF = low battery power
	*Blue LED on = device is on but position is not fixed
	*Blue LED flashing 1 sec. ON/2 sec. OFF = position is fixed
	*Blue LED flashing fast = Data tag to set point is successful



2.2.2 CONNECTING TO A COMPUTER

1. Turn on GPS logger.
2. Plug USB connector into USB port on computer.
3. Open CanWay.
4. Once connected, configurations and preferences can be updated.

2.2.3 HOW TO CHANGE CONFIGURATIONS

1. From the main screen, click on the "Logger" tab at the top of screen then click "Configuration"
2. In the Configuration menu, the logging interval can be changed by time or distance and the minimum logging speed can be set.
3. From the main screen, click on the "Tool" tab at the top of the screen then click "Options"
4. In the Options menu, many options can be changed; however, the "Unit" tab is the most applicable because the measures of altitude and latitude/longitude can be changed here.

2.2.4 CONFIGURATION FOR INDIAN CREEK STUDY

- Log at a 5 second time interval

- Minimum logging speed is 0 km/hour
- GPS location is measured in decimal degrees
- Elevation is measured in meters

3 DATA COLLECTION

GPS data collection in this study has two components:

Component 1 will focus on analyzing user density and temporal patterns of use by tracking rock climbers for a 24-hour period. Rock climbers will be intercepted at their campsite in order to allow for the natural dispersion of participants to their desired climbing area.

Component 2 will focus on analyzing informal trail use at several climbing walls of interest. Climbing walls of interest are areas with special management concerns including land degradation, resource overuse, informal trail proliferation, and user crowding. Rock climbers will be intercepted at the trailhead or parking lot of each climbing wall of interest in order to focus on user travel patterns at that particular climbing wall.

3.1 PREPARATION

1. Data loggers should be fully charged and have the proper configurations preset.
2. Arrive at the parking lot or entrance to the climbing area at daybreak.
3. Upon arrival, turn all of the units on.

3.2 INTERACTION WITH STUDY PARTICIPANTS

All participants will be given a three digit number starting at 001.

3.2.1 APPROACHING PARTICIPANTS

Participants will be approached in either their campsite or the parking lot or trailhead of the climbing areas of interest depending on the study. They will be informed about the studies purpose and objectives and expectations as participants.

Hi, my name is _____. I'm from the University of Utah. I am conducting a study of the spatial distribution of rock climbers in Indian Creek. I am asking that you carry this small GPS unit with you for the next 24-hours (Component 1)/for your time at this climbing area (Component 2) as well as fill out a very short questionnaire. Participation is voluntary and your questionnaire responses are confidential. Results from this study will be reported in broad statistical terms. Would you be willing to participate today?

If No: OK. Thank you for your time. Have a good day.

IF Yes: OK. Thank you for agreeing to participate. Here is the GPS unit and questionnaire.

Once the Questionnaire is Completed: Thank you very much for supporting this study. I will return to this campsite tomorrow night to retrieve the GPS unit (Component 1)/Please drop this GPS unit off in this drop box when you are leaving this climbing area (Component 2).

3.2.2 PARTICIPANT INSTRUCTIONS

Participants will be asked to carry the GPS Logger on their person for the entire time specified (24-hours or time in the climbing area). They must be willing to participate in the questionnaire as well as carry the GPS unit.

3.2.3 PARTICIPANT QUESTIONNAIRE

After agreeing to participate in the study, participants will fill out a short questionnaire as seen below:

Name: _____ E-mail address: _____

Campsite Area: _____ Campsite #:_____ Phone #:_____

Please tell us about *your past experience* as a rock climber.

Including today, approximately how many days in the last year have you been rock climbing (in & outside)? _____

Including today, approximately how many days in the last year have you been rock climbing at Indian Creek? _____

How many total years have you been rock climbing at Indian Creek? _____

On average, what grade of climb do you typically *lead* climb in Indian Creek (N/A if you do not lead)? _____

Please indicate your rock climbing skill level.

Novice ◄——— Intermediate ———► Advanced								
1	2	3	4	5	6	7	8	9

Please indicate how much each description of a rock climber describes you.

	Not at all Like me ◄——► A lot like me								
Rock climbing is an enjoyable, but infrequent activity that is secondary to other travel and outdoor interests. I am not highly skilled, rarely read articles about climbing and do not own much equipment beyond the basic necessities.	1	2	3	4	5	6	7	8	9
Rock climbing for me is important, but I do other outdoor activities too. I occasionally read articles about climbing & purchase equipment for climbing. My participation in rock climbing is inconsistent and I am moderately skilled.	1	2	3	4	5	6	7	8	9
Rock climbing is my primary outdoor activity. I purchase increasing amounts of equipment for rock climbing, participate in rock climbing every chance I get, consider myself highly skilled in climbing, and frequently read about climbing.	1	2	3	4	5	6	7	8	9

Demographic Information

1. What is your zip code (or country if outside the U.S.)? _____
2. In what year were you born? _____
3. What is your gender? (check one)

☐ Male ☐ Female

4. What is the highest level of school you have completed? (check one)

☐ Less than high school ☐ Some college ☐ Graduate degree
☐ Some high school ☐ Two-year college graduate ☐ Do not wish to answer
☐ High school graduate ☐ Four-year college graduate

5. What is your race/ethnicity? (check all that apply)

☐ American Indian ☐ Hawaiian/Pacific Islander ☐ Other
☐ Asian ☐ Hispanic/Latino ☐ Do not wish to answer
☐ Black/African American ☐ White

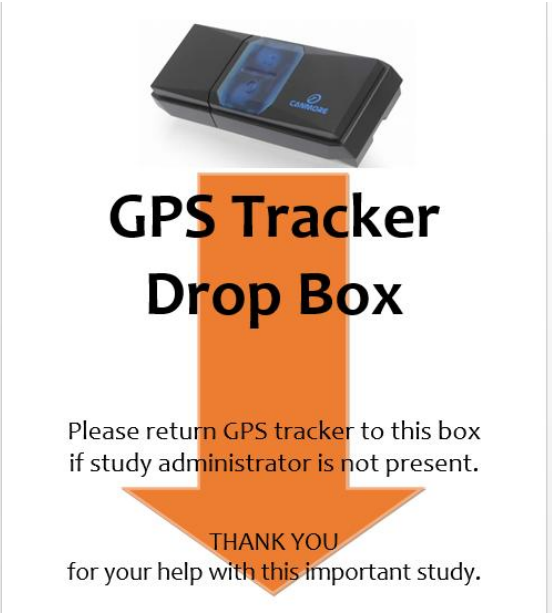
6. Which category best describes your total household income in U.S. dollars during 2013 before taxes?

☐ Less than $24,999 ☐ $50,000 to $74,999 ☐ $150,000 to $199,999
☐ $25,000 to $34,999 ☐ $75,000 to $99,999 ☐ $200,000 or more
☐ $35,000 to $49,999 ☐ $100,000 to $149,999 ☐ Do not wish to answer

Researcher Use Only: Date: _____ Participant #: _____ Climbing Area: _____ Time: _____

3.2.4 COLLECTING DATA LOGGERS

Data loggers will either be collected in person by the study coordinator or participants will be asked to place the GPS loggers in drop box at the same location the units were given to participants. The drop box will be secured to a sturdy object and have a sign above it to remind participants to drop off the unit.



4 DOWNLOADING DATA

4.1 USING CANWAY TO TAKE DATA OFF OF DATA LOGGERS

1. Turn on unit.
2. Plug USB into computer.
3. Open CanWay program.
4. Click the "Logger" tab at the top of the main screen, then click "Download Trip"
5. The "Add Activities Wizard" will open with the "Select Activities to Import" section. Select the appropriate files to download by checking the date, then click next at the bottom of the wizard.
6. The "Add Activities Wizard" will open with the "Review Activity Detail" section. Here, the file can be renamed, the type of activity can be recorded, or the time zone can be changed if needed.
    a. For the purpose of the Indian Creek project, the Participant # will be added to the beginning of the file name at this point.
    b. File names should look like this originally: 2014-01-19 17-50
    c. File names should look like this after Participant # is added: 001 2014-01-19 17-50
    d. For the purpose of the Indian Creek project, there is no need to categorize the files by activity type within the CanWay program.
7. Click "Next" then "OK" to finish and exit the wizard.

4.2 EXPORTING DATA TO .CSV FORMAT

1. Click the "File" tab at the top of the main screen, then "Export", then "CSV"
2. Browse to the appropriate folder location, then click save.
3. A window will open that says "Export Successful", Click "OK"
4. Files names should look like this at this point: export_001 2014-01-19 17-50
5. Save all files twice – once in an "Original Data" folder for data back up and once in an "Active Data" folder for data manipulation.
6. All data should be backed up onto an external drive once per day.

4.3 DATA STORAGE

Data will be stored in the following folders and subfolders and backed up onto an external drive once per day:

- *Folder* - Original Data
    - *Subfolder* - Original Files will be saved in subfolders by Date
- *Folder* - Active Data
    - *Subfolder* - Original Files will be saved in subfolders by Date
    - *Subfolder* - Combined Single Participant Files (if necessary)
    - *Subfolder* - Edited Single Participant Files
    - *Subfolder* - Combined Daily Samples Files
    - *Subfolder* - Combined All Participant File

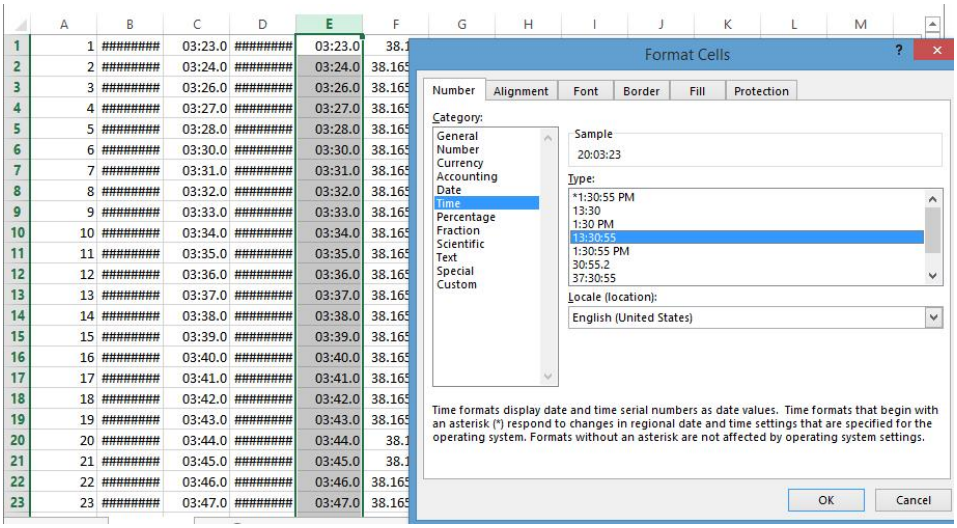
4.4 Clearing Data From Data Loggers

1. Clear data from the units only *after* files have been exported and saved in .csv format
2. Click the "Logger" tab at the top of the main screen, then click "Clear Trip"
3. A window will open that says "Erase the trip from GPS logger", Click "OK"
4. A window will open that says "Erase successful", Click "OK"
5. Remove data logger from computer, turn off unit, and replace USB cover for storage.

4.5 Manipulation of CSV Files

4.5.1 Initial Manipulation

1. Combine multiple CSV files from a single participant if necessary (see section 4.6)
2. Reformat column E to military time (from 00:00:00 to 24:00:00) by right clicking on the "E" at the top of the column, click "Format Cells…", under the "Number" tab click "Time", then use the format 00:00:00 (as seen below).



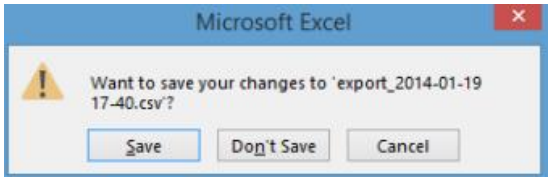
3. Delete columns B and C, date and time columns – these consist of an extra data column and an inaccurate time column.
4. Insert two columns – A and B:
    a. A will be for the "Participant #"
    b. B will be the "Unit ID #"
5. Column C will be the "Point ID #" – to number rows in numerical order (1,2,3, etc…)
6. Clean data from each participant by deleting all data recorded before handing the device to the participant (this will occur because data loggers will be turned on in the parking lot or trailhead well before giving the unit to a participant).
7. At this point your data will look like this:

	A	B	C	D	E	F	G	H	I	J	K
1	1	1	1	1/19/2014	17:40:37	40.70257	N	111.8259	W	1410.8	1
2	1	1	2	1/19/2014	17:42:26	40.70278	N	111.8258	W	1397.9	0

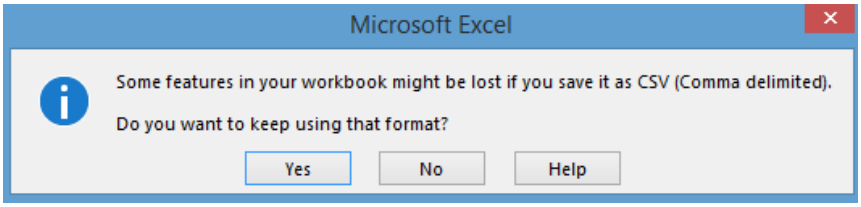
8. Save the edited file under the Subfolder - Edited Daily Participant Files
9. Combine the edited daily participant files from each day using Command Prompt and save the combined file under the Subfolder – Combined Daily Samples

4.5.2 *Manipulation of Data after Combining CSV Files*

1. When all CSV files are edited and combined into the "Combined Daily Samples", open the spreadsheet.
2. Delete the G and I columns (those that say N and W).
3. Insert column to the left of column G - the Longitude column (it will be "109.xxx).
4. Put a negative symbol (-) at the top of the new column G (in grid G1), and copy/paste the negative symbol into the remaining rows.
5. Insert a column to the right of the Longitude column (now column I). Type "=concatenate(" in grid I1, then click on the grid with the negative symbol (G1), then enter a comma (,), then click on the longitude (H1), then end with a parenthesis. It should now look like this: "=concatenate(G1,H1)". Click enter.
6. This will combine the negative symbol and the parenthesis into your new column.
7. Format the new negative longitude as a number value by Right clicking on the top of column I, right click "Format Cells…", select "Number" as the category, then click OK.
8. Exit the program by clicking the "X" in the top right-hand corner.
9. A window will appear that says:



10. Click Save.
11. The "Save As" window will appear. Click Save at the bottom of the window.
12. A window will appear that says:



13. Click Yes.
14. Re-open the same file.
15. Delete the old columns with the negative symbol (column G) and old longitude (column H).
16. The file should now look like this:

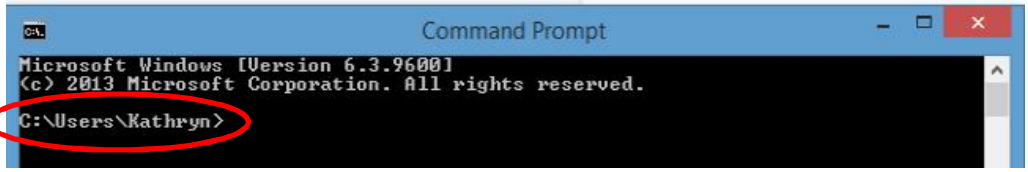
	A	B	C	D	E	F	G	H	I
1	1	1	1	1/19/2014	17:40:37	40.70257	-109.826	1410.8	1
2	1	1	2	1/19/2014	17:42:26	40.70278	-109.826	1397.9	0

17. Make sure participant # (A), unit # (B), point # (C), latitude (F), longitude (G), altitude (H), and speed (I) columns are formatted as numbers.

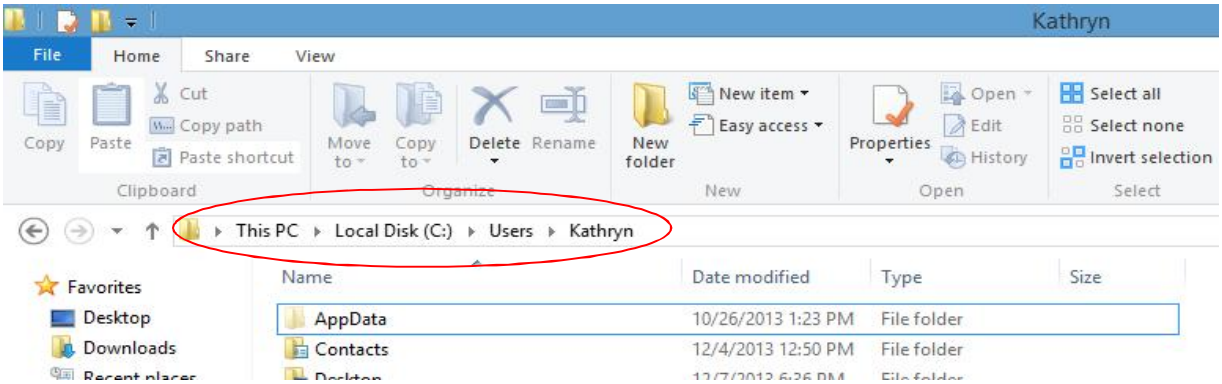
4.6 When Multiple Tracks Need to Be Combined

If multiple .csv files exist for a single unit, combine using Windows Command Prompt:

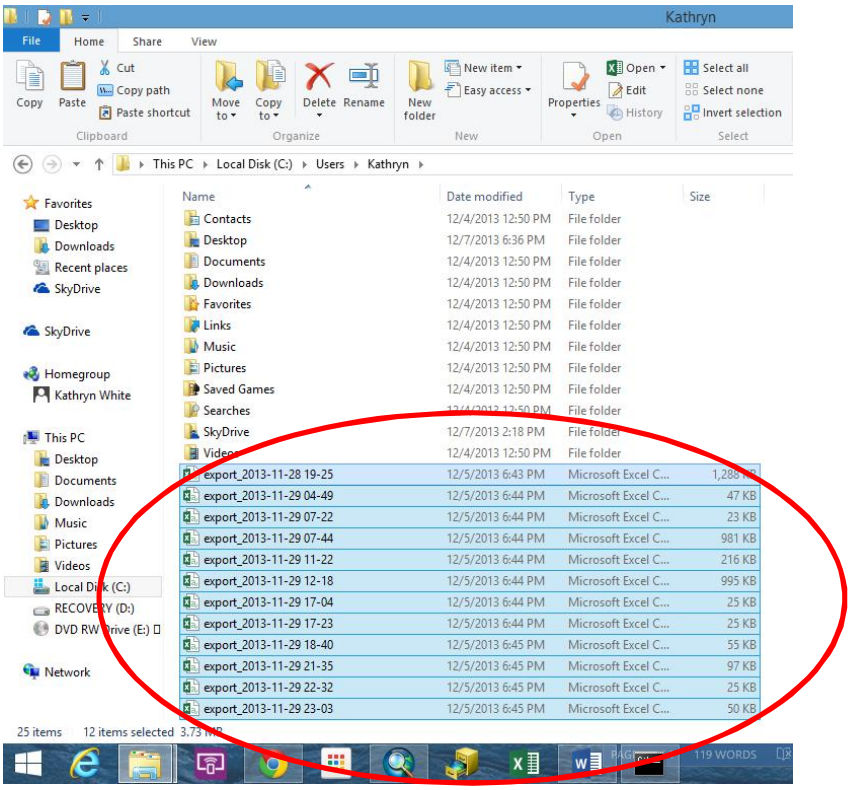
1. Search for Command Prompt in the Search menu, then open Command Prompt
2. Open the folder that Command Prompt automatically opens to (this example is C:\Users\Kathryn)



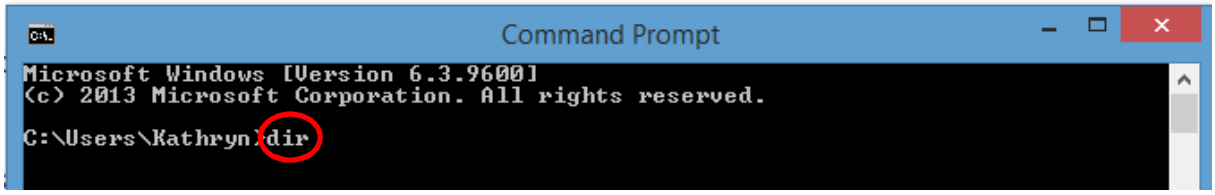
3. Open the folder used by Command Prompt



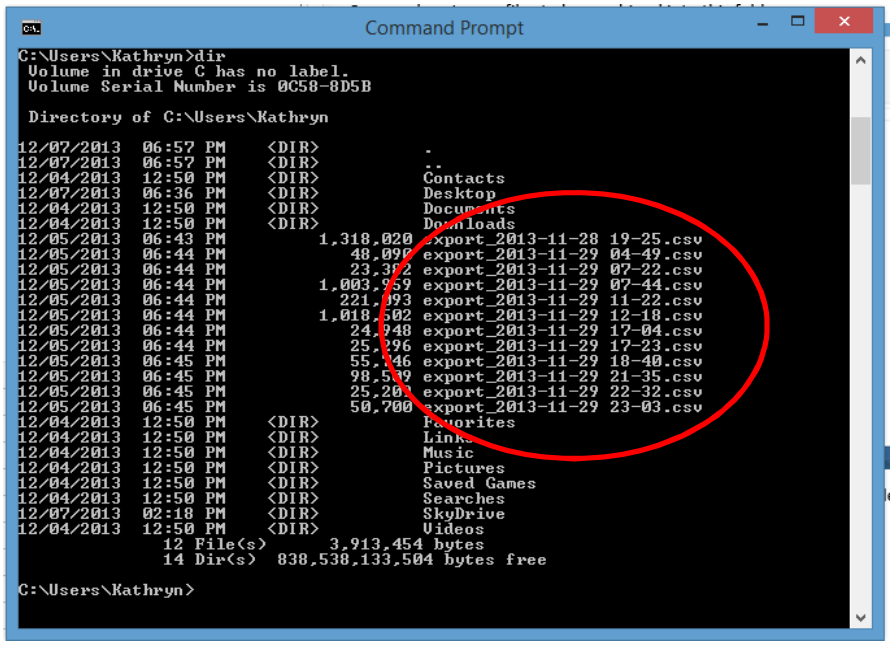
4. Copy and paste .csv files to be combined into this folder.



5. In Command Prompt, type the command dir



6. Press Enter to ensure the correct files are in the folder.



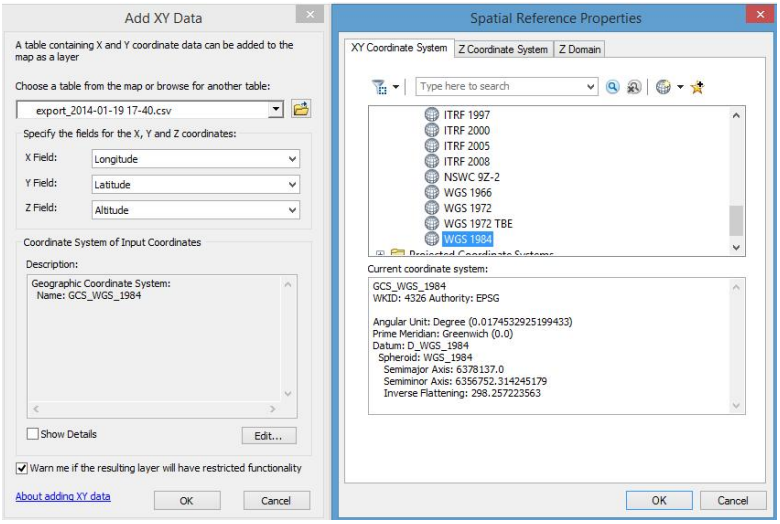
7. Type the command copy *.csv newfile.csv to merge all CSV files in the folder into a new CSV file titled “newfile.csv” (any name can be used)
8. The new combined file will be located in the C:\Users\Kathryn folder. Transfer combined files to the appropriate folder.

5 USING ARCMAP

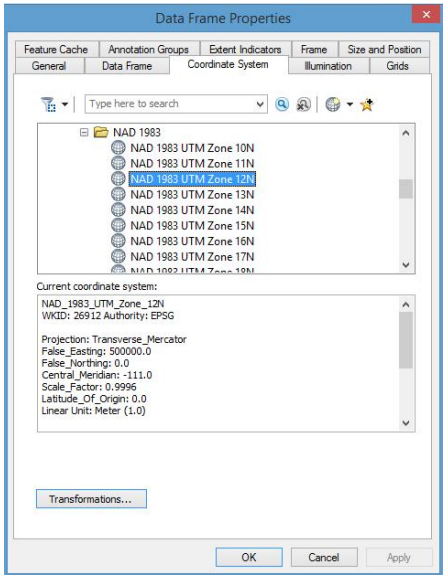
Data should be entered into ArcMap at least once per week and cleaned.

5.1 IMPORTING CSV FILES INTO ARCMAP

1. Open ArcMap.
2. Insert the edited and combined data, by right clicking on File, then Add Data, then Add X Y Data...
3. Choose the appropriate file in the browse menu. Click OK.
4. The “Add XY Data” window will open.
5. In the “Add XY Data” window, X Field = Longitude. Y Field = Latitude. Z Field = Altitude.
6. In the “Add XY Data” window, click the Edit button to change the Coordinate System of Input Coordinates to the “Geographic Coordinate System of WGS 1983” by clicking on “Geographic Coordinate System”, then “World”, then “WGS 1983”. Then click OK and then OK.



7. Make sure the Layer Coordinate System has been set to “NAD 1983 UTM Zone 12N” by right clicking on the Layer under Table of Contents, clicking on Properties, and then change the Coordinate System to the “Projected Coordinate System of NAD 1983 UTM Zone 12N” by clicking on “Projected Coordinate System”, then “UTM”, then “NAD 1983”, then “NAD 1983 UTM Zone 12N”. Then click OK and then OK.



8. Then export the recently added XY data by right clicking on the file under the Layer, click on Data, then Export Data. Click OK.
9. All points will be added as one dataset.
10. Remove the original file from the layer.

Appendix B:

Map: Indian Creek Climbing Walls & Trails

Indian Creek Climbing Walls & Trails (North Climbing Areas)

SUBURBIA
THE WALL
75 CAIRNS
ELECTION WALL
Creek Pasture Campground
THE BACK WALL
CLIFFS OF INSANITY
SACRED COW
ORIGINAL MEAT WALL
Superbowl Campground
NORTH SIX SHOOTER
TENDERLOINS
2ND MEAT WALL
1ST MEAT WALL
SOUTH SIX SHOOTER
SELFISH WALL
SIX STAR WALL
SHOCK AND AWE
DISAPPOINTMENT CLIFFS
PUBLIC SERVICE WALL
THE FIN
BROKEN TOOTH

Legend

- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- State Highway
- Class B Road
- Class D Road
- ATV Trail/Wash

N

0 0.25 0.5 1 1.5 2 Miles

Indian Creek Climbing Walls & Trails (Central Climbing Areas)

SIX SHOOTER
SELFISH WALL
SIX STAR WALL
SHOCK AND AWE
DISAPPOINTMENT CLIFFS
PUBLIC SERVICE WALL
THE FIN
BROKEN TOOTH
SLUG WALL
CAT WALL
BRIDGER JACK MESA
Bridger Jack Primitive Campground
RESERVOIR WALL
LOVE WALL
PODS WALL
OPTIMATOR
4X4 WALL
PETRIFIED HORNET
211
SCARFACE
POWER WALL
ALTITUDE WALL
FRINGE OF LIFE
CACTUS FLOWER BUTTRESS
TECHNICOLOR WALL
TRICKS WALL
FRINGE OF DEATH
OVER THE HILL
SCORPION CORNER
THE GASH
SINBAD
NEW WAVE

Legend

- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- State Highway
- Class B Road
- Class D Road
- ATV Trail/Wash

N

0 0.25 0.5 1 1.5 2 Miles

Indian Creek Climbing Walls & Trails (South Climbing Areas)

TECHNICOLOR WALL
OVER THE HILL
THE GASH
TRICKS WALL
FRINGE OF DEATH
SCORPION CORNER
SINBAD
NEW WAVE WALL
BATTLE OF THE BULGE
DONNELLY CANYON
SPARKS WALL
WAY RAMBO
SUPERCRACK BUTTRESS
CRITICS CHOICE
Cottonwood Primitive Campground
BIOTURBATION
BLUE GRAMMA
SABBATICAL WALL
THE PROW
PISTOL WHIPPED WALL
211
FRICTION SLABS
VITAMIN D WALL
Newspaper Rock

Legend

- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- State Highway
- Class B Road
- Class D Road
- ATV Trail/Wash

N

0 0.25 0.5 1 1.5 2 Miles

Appendix C:

Map: GPS Visitor Tracking

GPS Visitor Tracking in Indian Creek (North Climbing Areas)

SUBURBIA
THE WALL
75 CAIRNS
ELECTION WALL
Creek Pasture Campground
THE BACK WALL
CLIFFS OF INSANITY
SACRED COW
ORIGINAL MEAT WALL
Superbowl Campground
NORTH SIX SHOOTER
TENDERLOINS
2ND MEAT WALL
1ST MEAT WALL
SOUTH SIX SHOOTER
SELFISH WALL
SIX STAR WALL
SHOCK AND AWE
DISAPPOINTMENT CLIFFS
PUBLIC SERVICE WALL
THE FIN
BROKEN TOOTH

Legend

- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- GPS Visitor Tracking

N

0 0.25 0.5 1 1.5 2 Miles

GPS Visitor Tracking in Indian Creek (Central Climbing Areas)

SIX SHOOTER
SELFISH WALL
SIX STAR WALL
SHOCK AND AWE
DISAPPOINTMENT CLIFFS
PUBLIC SERVICE WALL
THE FIN
BROKEN TOOTH
SLUG WALL
CAT WALL
BRIDGER JACK MESA
Bridger Jack Primitive Campground
RESERVOIR WALL
LOVE WALL
PODS WALL
OPTIMATOR
4X4 WALL
PETRIFIED HORNET
211
SCARFACE
POWER WALL
ALTITUDE WALL
FRINGE OF LIFE
CACTUS FLOWER BUTTRESS
TECHNICOLOR WALL
TRICKS WALL
FRINGE OF DEATH
OVER THE HILL
SCORPION CORNER
THE GASH
SINBAD
NEW WAVE

Legend

- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- GPS Visitor Tracking

N

0 0.25 0.5 1 1.5 2 Miles

GPS Visitor Tracking in Indian Creek (South Climbing Areas)

TECHNICOLOR WALL
TRICKS WALL
FRINGE OF DEATH
OVER THE HILL
SCORPION CORNER
THE GASH
SINBAD
NEW WAVE WALL
BATTLE OF THE BULGE
SPARKS WALL
WAY RAMBO
DONNELLY CANYON
SUPERCRACK BUTTRESS
CRITICS CHOICE
Cottonwood Primitive Campground
BIOTURBATION
BLUE GRAMMA
SABBATICAL WALL
THE PROW
PISTOL WHIPPED WALL
211
FRICTION SLABS
VITAMIN D WALL
Newspaper Rock

Legend

- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- GPS Visitor Tracking

N

0 0.25 0.5 1 1.5 2 Miles

Appendix D:

Map: Signage Recommendations

Indian Creek Climbing Walls & Trails: Narrative Signage Recommendations (North Climbing Areas)

SUBURBIA
THE WALL
75 CAIRNS
ELECTION WALL
THE BACK WALL
CLIFFS OF INSANITY
SACRED COW
ORIGINAL MEAT WALL
TENDERLOINS
2ND MEAT WALL
1ST MEAT WALL
SELFISH WALL
SIX STAR WALL
SHOCK AND AWE
DISAPPOINTMENT CLIFFS
PUBLIC SERVICE WALL
BROKEN TOOTH
THE FIN
Creek Pasture Campground
Superbowl Campground
NORTH SIX SHOOTER
SOUTH SIX SHOOTER

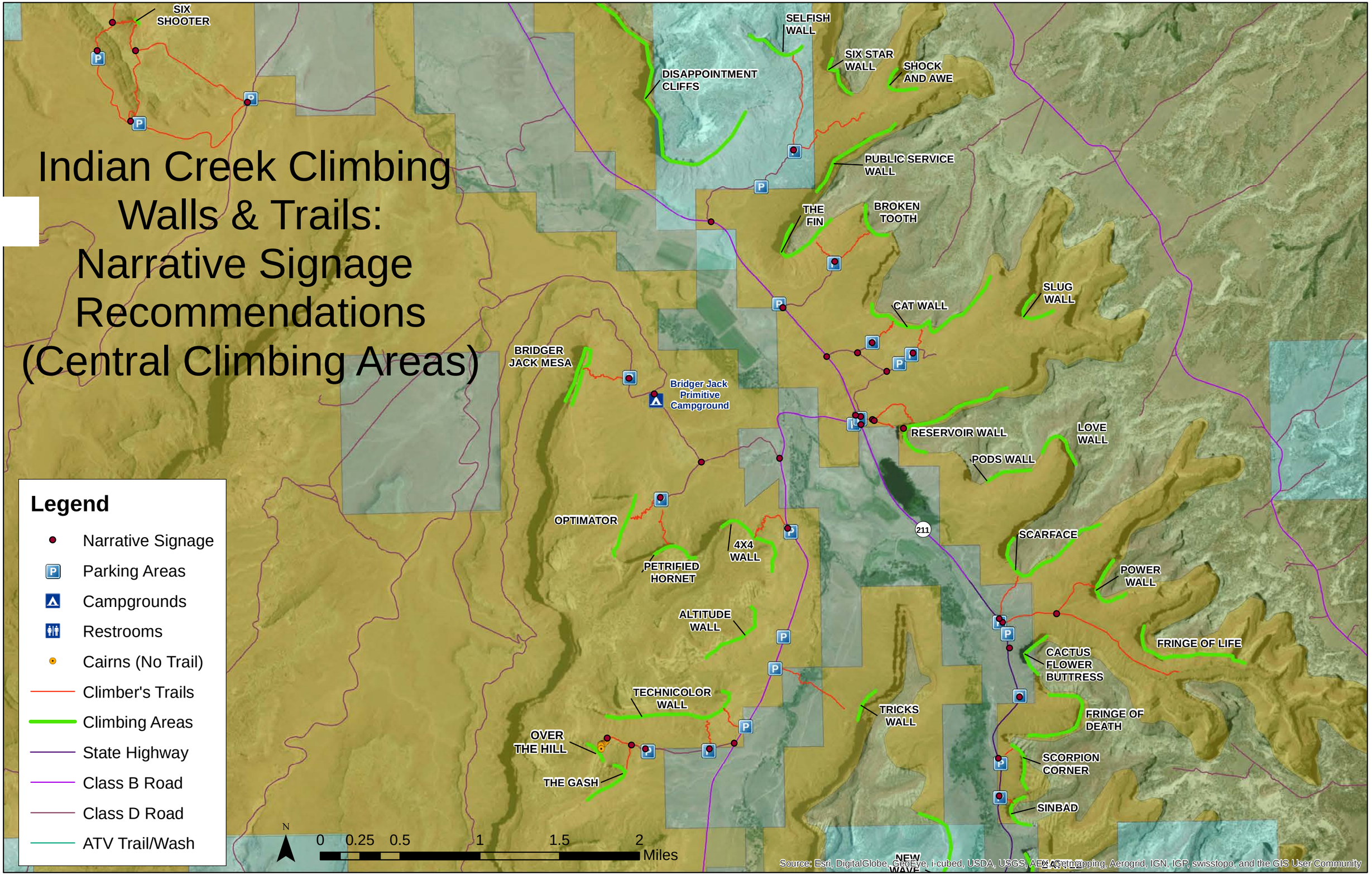
Legend

- Narrative Signage
- Parking Areas
- Campgrounds
- Restrooms
- Cairns (No Trail)
- Climber's Trails
- Climbing Areas
- State Highway
- Class B Road
- Class D Road
- ATV Trail/Wash

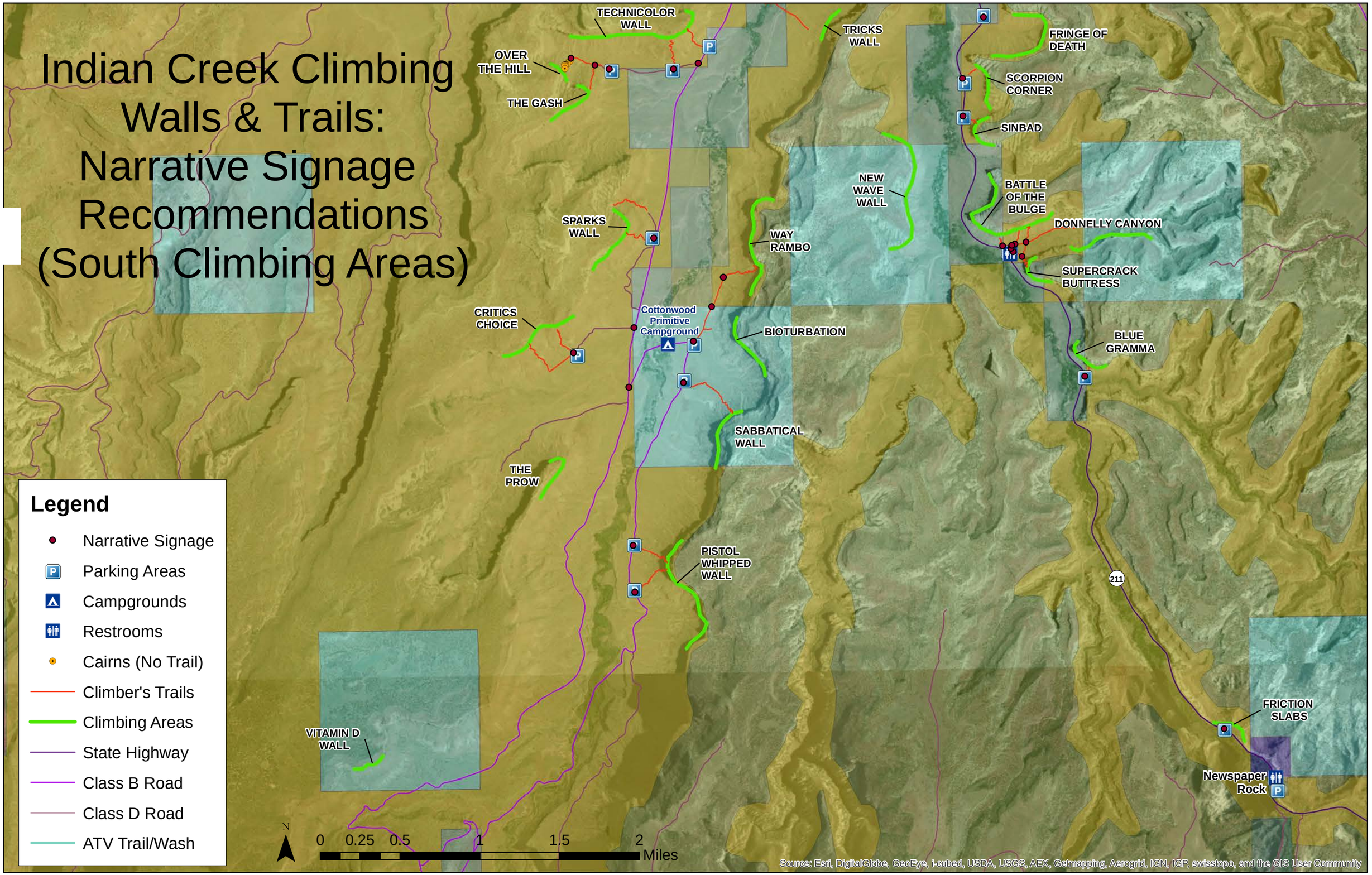
N

0 0.25 0.5 1 1.5 2 Miles

Indian Creek Climbing Walls & Trails: Narrative Signage Recommendations (Central Climbing Areas)



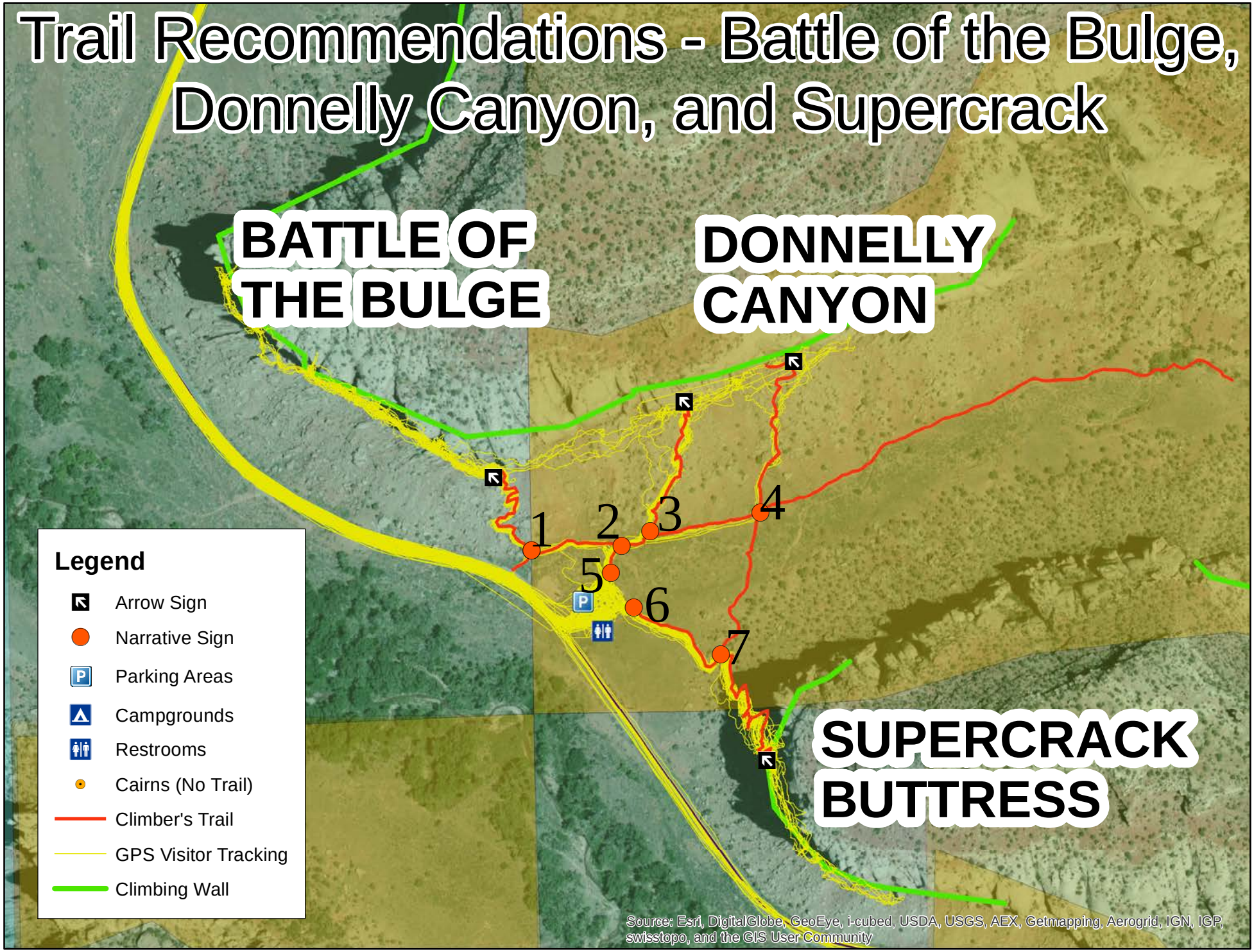
Indian Creek Climbing Walls & Trails: Narrative Signage Recommendations (South Climbing Areas)



Appendix E:

Maps & Recommendations for the Top 5 Visited Climbing Areas

Trail Recommendations - Battle of the Bulge, Donnelly Canyon, and Supercrack



Appendix E:
Narrative Sign Recommendations for
Battle of the Bulge, Supercrack, Donnelly Canyon

Narrative Sign #1

Battle of the Bulge	↑
Donnelly Canyon	→

Narrative Sign #2

Battle of the Bulge	←
Donnelly Canyon	→

Narrative Sign #3

Donnelly Canyon	↑
(Left Side of Wall)	

Narrative Sign #4

Donnelly Canyon	←
(Right Side of Wall)	
Supercrack Buttress	→

Narrative Sign #5

To Donnelly Canyon	↑
& Battle of the Bulge	

Narrative Sign #6

Supercrack Buttress	↑

Narrative Sign #7

Supercrack Buttress	↑
Donnelly Canyon	←


Trail Recommendations - Cat Wall
CAT WALL
1
2
3
4
5
Legend
Arrow Sign
Narrative Sign
Parking Areas
Campgrounds
Restrooms
Cairns (No Trail)
Climber's Trail
GPS Visitor Tracking
Climbing Wall
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Appendix E:
Narrative Sign Recommendations for
the Cat Wall

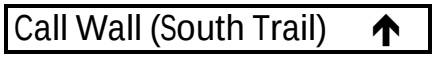
Narrative Sign #1

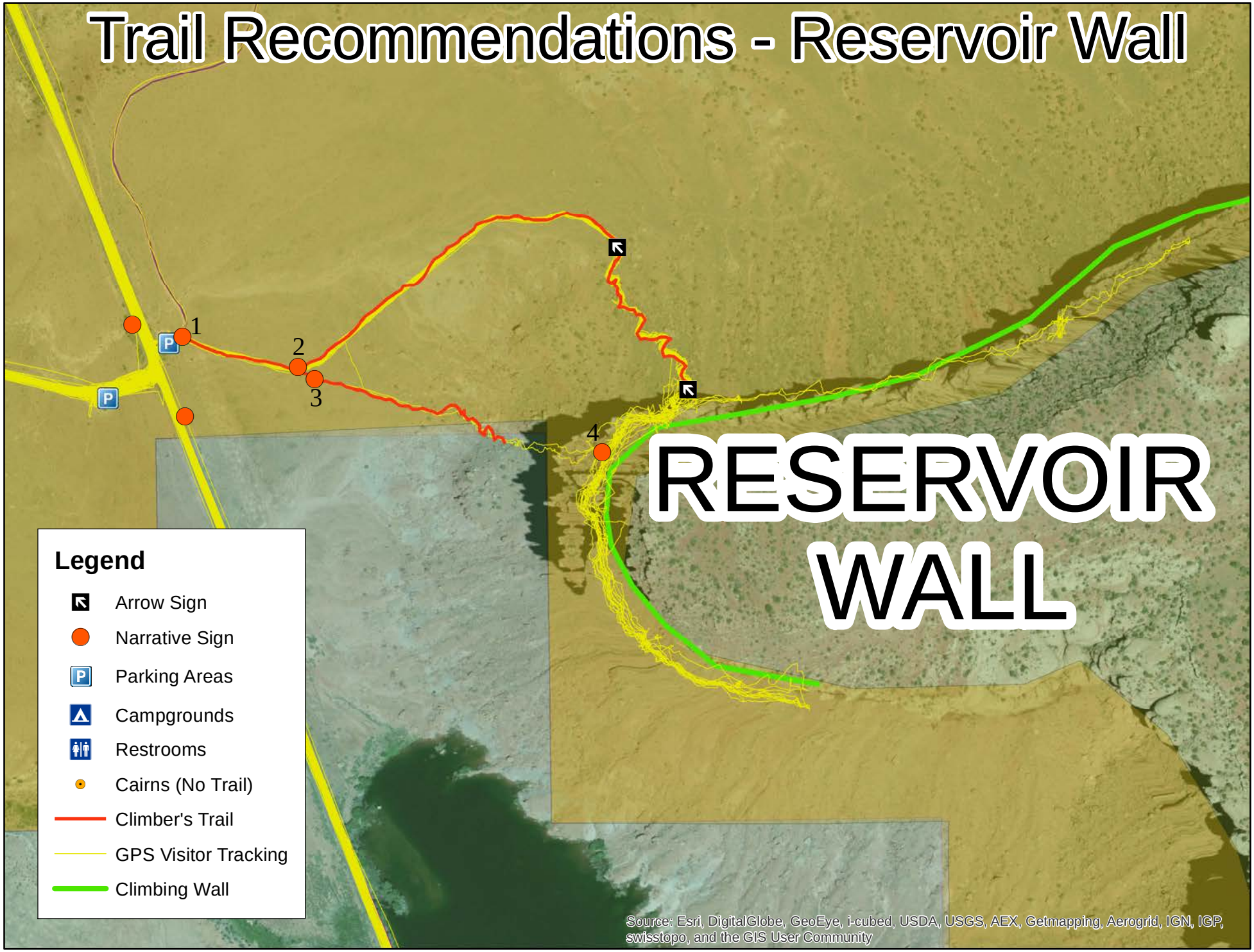
Narrative Sign #2

Narrative Sign #3

Narrative Sign #4

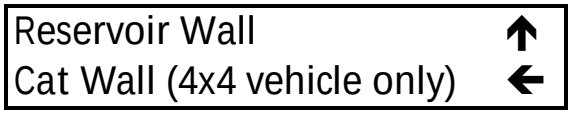
Narrative Sign #5




Trail Recommendations - Reservoir Wall
1
2
3
4
RESERVOIR WALL
Legend
Arrow Sign
Narrative Sign
Parking Areas
Campgrounds
Restrooms
Cairns (No Trail)
Climber's Trail
GPS Visitor Tracking
Climbing Wall
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Appendix E:
Narrative Sign Recommendations for
the Reservoir Wall

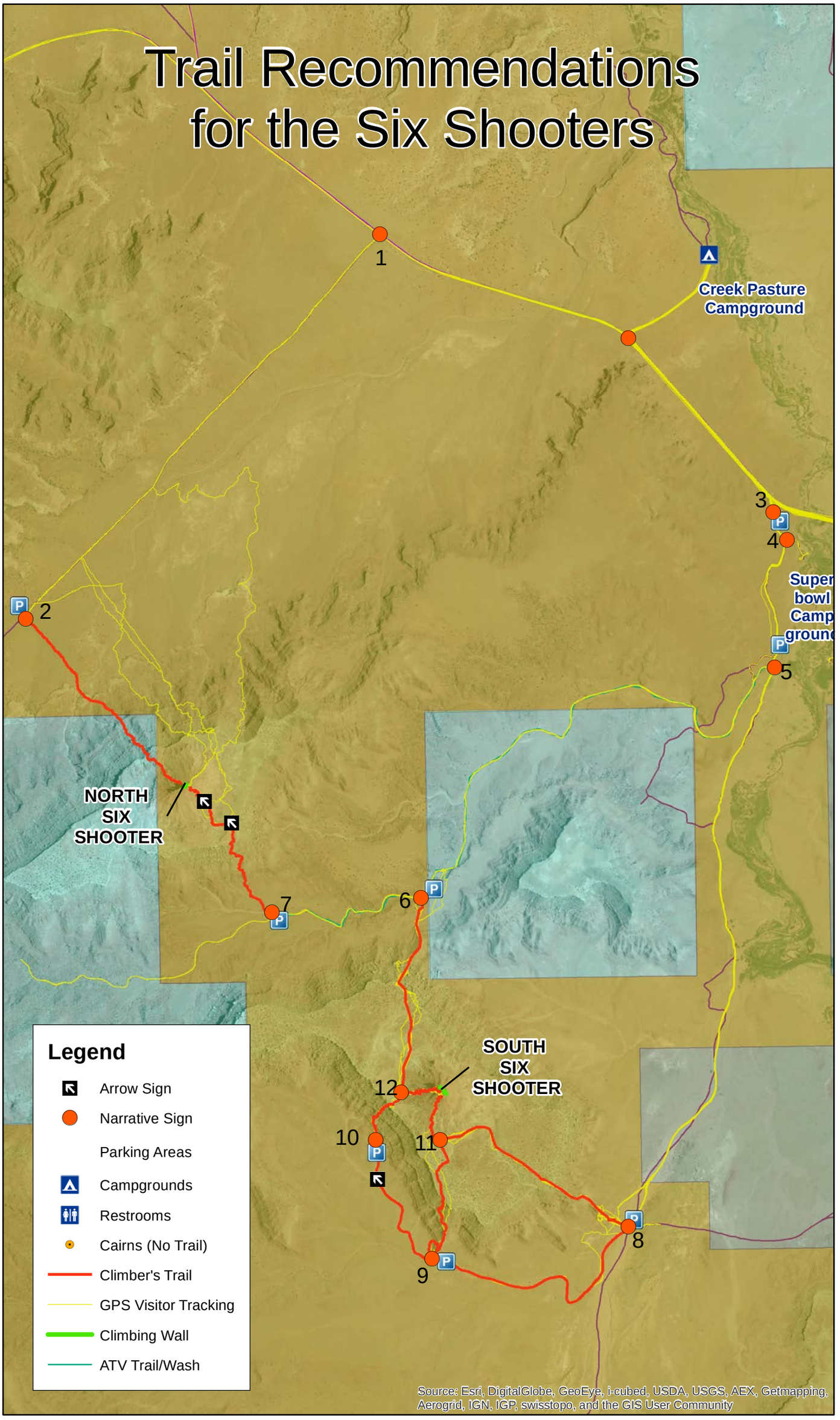
Narrative Sign #1



Narrative Sign #2

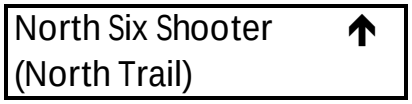
Narrative Sign #3

Narrative Sign #4

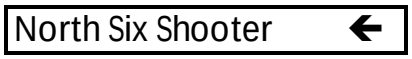

Trail Recommendations for the Six Shooters
1
Creek Pasture Campground
3
4
Super bowl Camp ground
2
5
NORTH SIX SHOOTER
7
6
SOUTH SIX SHOOTER
12
10
11
8
9
Legend
Arrow Sign
Narrative Sign
Parking Areas
Campgrounds
Restrooms
Cairns (No Trail)
Climber's Trail
GPS Visitor Tracking
Climbing Wall
ATV Trail/Wash
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Appendix E:
Narrative Sign Recommendations for
the Six Shooters

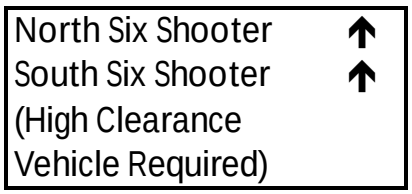
Narrative Sign #1



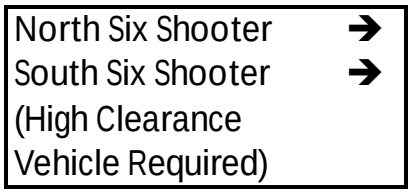
Narrative Sign #2



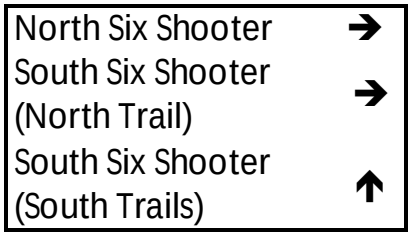
Narrative Sign #3



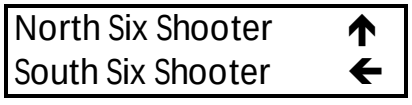
Narrative Sign #4



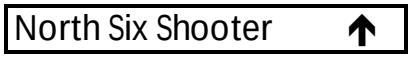
Narrative Sign #5



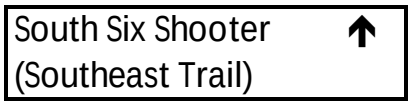
Narrative Sign #6



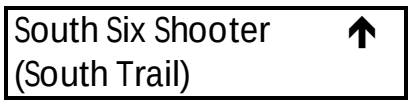
Narrative Sign #7



Narrative Sign #8

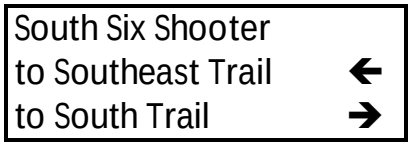


Narrative Sign #9



Narrative Sign #10

Narrative Sign #11



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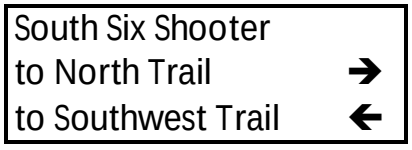
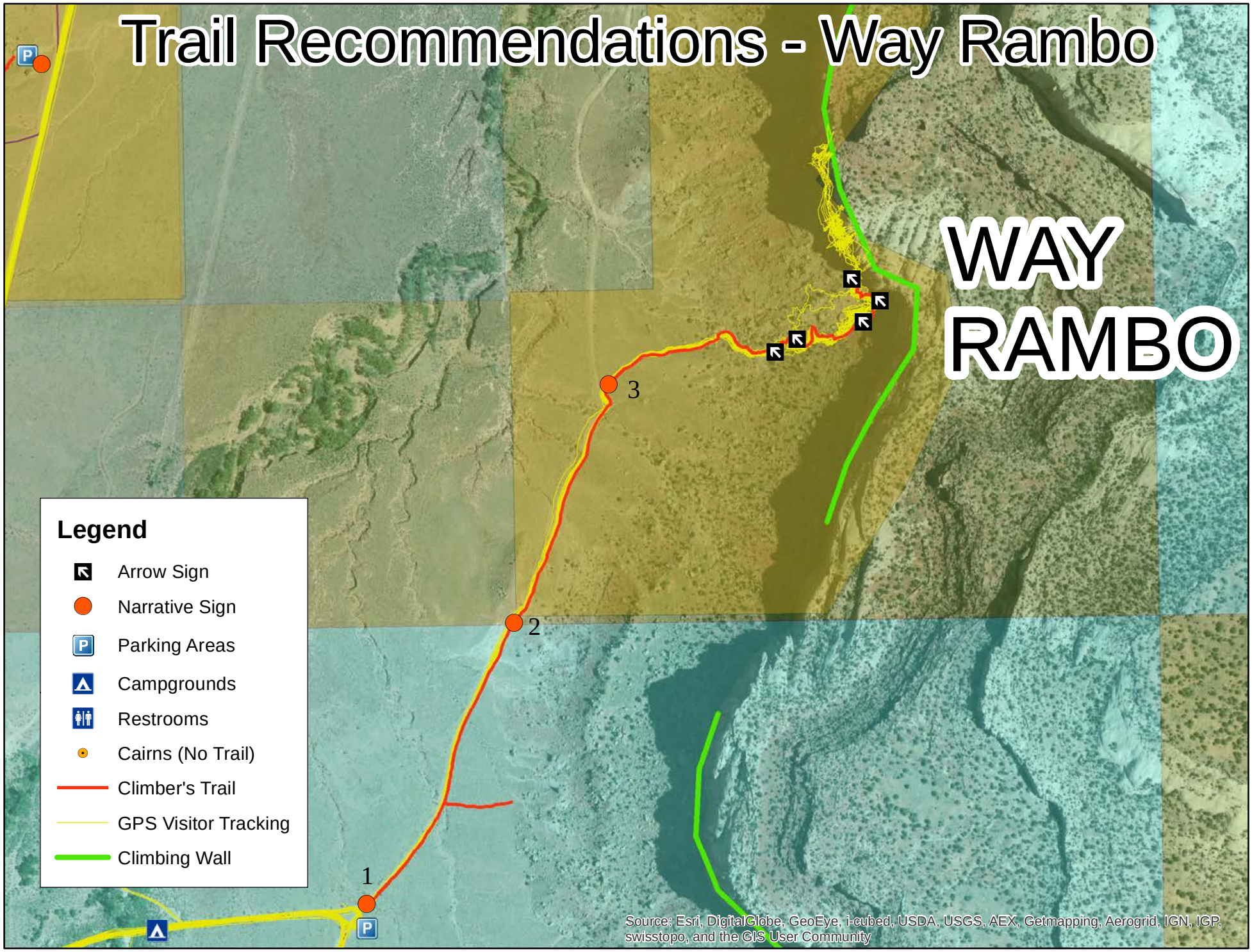
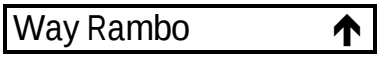


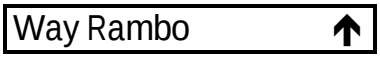

Trail Recommendations - Way Rambo
WAY RAMBO
Legend
Arrow Sign
Narrative Sign
Parking Areas
Campgrounds
Restrooms
Cairns (No Trail)
Climber's Trail
GPS Visitor Tracking
Climbing Wall
1
2
3
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Appendix E:
Narrative Sign Recommendations for
Way Rambo

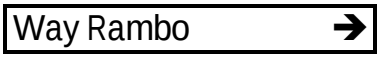
Narrative Sign #1



Narrative Sign #2



Narrative Sign #3



Appendix F:

Indian Creek Climbing Trail Quality and Access

Climbing Area	Overall Trail Condition	Quality Comments	Access Comments
1st Meat Wall	Partially Good	Sporadically good, but disapears in sections	Trail start is difficult to find since the trail begins well away from either possible parking area. Cairns help to find this sporadic trail.
2nd Meat Wall	Partially Good	Good about halfway up, then extremely crumbly	Long walk or high clearance vehicle required. Trail start is very easy to find. Most of trail is easy to follow.
4 x 4 Wall	Excellent	Great rock stairs	Easy access from Beef Basin Road. It can be hard to find the start, but then is an exellent trail for the most part. May be confusing closer to the wall.
75 Cairns	Good	Loose in a couple sections	Accessed by "The Wall" trail or "Election Wall" trail.
Altitude Wall	No Trail	No Trail	While there is a pull off with a no camping sign in front of the wall, there is no trail. Can be accessed by 4x4 Wall.
The Back Wall	No Trail	No Trail	Long walk or high clearance vehicle required to access. No trail.
Battle of the Bulge Buttress	Excellent	Well marked	Short, easy trail with great access.
Bioturbation Wall	No Trail	No Trail	No Trail.
Blue Gramma Cliff	Excellent	Well marked	Short, easy trail with great access.
The Bridger Jacks	Good	Well marked with cairns	Long walk or high clearance vehicle required to access through Bridger Jacks Primitive Camping Area. Well marked with cairns until about 30 feet from the wall.
Broken Tooth	Excellent	Easy to find and well marked	High clearance vehicle recommended to access. Trail easy to find and is mostly great quality.
Cactus Flower Buttress	No Trail	No Trail	Several pulloffs on the highway could be used to access this wall, but no trail exists.
Cat Wall	Partially Good	Well traveled trails	Two trails - one to the north and one south. Although the trail to the south is better quality, parking is not allowed at the trailhead. The north trail is easy to find and most accessed, but several sections can be confusing and loose.
Cliffs of Insanity	Excellent	Well marked	Long walk or high clearance vehicle required to access. Easy to find once at the trailhead. There were reports of another trail access down a wash closer to the highway, unable to find.

Climbing Area	Overall Trail Condition	Quality Comments	Access Comments
Critic's Choice	Partially Good/Poor	Two Trails	Two trails - one to the north and one south. The trail to the north is extremely steep and loose. The trail to the south is an easy walk down a cow path then up a ridge with some loose sections.
Disappointment Cliffs	No Trail/Cairns only	No Trail/Cairns only	There are supposed to be two trails - on North side and on South side of cliffs. Located widely spaced cairns on north side up steep scree slopes. No trail found on the South side.
Donnelly Canyon	Poor	Extremely braided.	Two trails are easily accessed. However, both are extremely braided with washed out sections.
Election Wall	Poor	Loose, crumbly trail	Difficult to find, but a faint trail can be found in places by following sporadic cairns.
Fin Wall	Good	Loose in a couple sections	High clearance vehicle recommended to access. Trail is easy to find and is mostly good quality. Loose in several spots.
Friction Slab	No Trail	No Trail	A pull off exists on the side of the highway. An extremely faint trail can be found in sections.
Fringe of Death Canyon	No Trail	No Trail	A pull off exists on the side of the highway with a trail down an old road for several hundred yards. No Trail leads to any climbing.
Fringe of Life Canyon	No Trail	No Trail	This relatively unvisited area has no trails to walls. An old road exists at the base of the canyon.
The Gash	Poor	Steep, faint, and loose	Accessed by a road to the south of Technicolor Wall. Trail start is hard to find. Marked with cairns.
Love Wall	No Trail	No Trail	Accessed by walking across fields from Scarface and then up tallus.
New Wave Wall	No Trail	No Trail	Access is sensitive to this area since walking across private land is required. Can be accessed across from Donnolly Canyon parking lot. No trails.
North Six Shooter Peak	Partially Good	Two trails - one is good quality and easy to find, the other is not really a trail	Long walk or high clearance vehicle required. Two access points. One from a class D road just past Creek Pasture turn off. Not really a trail but a means to access since no trail really exists - cairns occassionally. The other trail is accessed down Davis Canyon Road and down a wash in between 6 shooters. This trail is well marked and easy to follow but somewhat crumbly in sections.

Climbing Area	Overall Trail Condition	Quality Comments	Access Comments
The Optimator	Partially Good	Very loose & hard to find in short sections	Long walk or high clearance vehicle required to access. Easy to locate in sections, but also has loose, confusing sections of trail.
The Original Meat Wall	Partially Good	Good until about 50 feet from wall, then multiple crumbling trails.	Long walk or high clearance vehicle required. Trail very easy to follow once at the trailhead until close to the wall.
Over the Hill	Poor	Cairns only, steep, and extremely loose	Accessed by a road to the south of Technicolor Wall. Trail start is hard to find. Very few cairns guide the climber up an extremely steep, loose slope.
Petrified Hornet Wall	Poor	Poor	Long walk or high clearance vehicle required. There is no trail until the slope is steeper, then the trail is loose and steep.
Pistol Whipped	Excellent/Partially Good	Two Trails	Two Trails - one to the north and one south. The trail to the south is brand new and just planned out - great condition. The trail to the north is very braided but good in several sections.
Pods Wall	No Trail	No Trail	Accessed by walking across fields either from Scarface or Reservoir and then up tallus.
Power Wall	Good	Mostly good, loose in sections	Easy to find. Follows old road to the north side of the wall. Then up partially loose talus on trail.
Public Service Wall	Cairns only	Very steep faint trail	Long walk or high clearance vehicle required to access. Extremely steep loose 'trail' marked by few cairns. There may be a second trail farther down the canyon, but unable to find. Most may access from The Fin.
Reservoir Wall	Partially Good	Two trails - one is good quality and easy to find, the other is extremely steep and loose	Easy to access. Two trails. The one to the north is great quality but seems less direct than the other trail. The trail to the south is located in a gully and is terrible quality but most direct.
Sacred Cow	Partially Good	No trail in sections	Very difficult to find from the parking area, but easy to find afterwards.
Sabbatical Wall	Poor	Not much of a trail	Very faint trail in the flat sections. Easier to follow once trail starts sloping.
Scarface	Good	Easy to follow	Very easy to access, slightly loose in sections, but overall good trail.
Scorpion Corner	No Trail	No Trail	An extremely faint section of trail can be found for about 50 feet but it is in terrible condition.

Climbing Area	Overall Trail Condition	Quality Comments	Access Comments
Selfish Wall	Good	Good until steep sections.	Long walk or high clearance vehicle required to access. Easy to find trail, but a couple sections are loose.
Shock and Awe	No Trail	No Trail	Long walk or high clearance vehicle required to access. Accessed by walking down a very long wash and then scrambling up talus.
Sinbad Wall	Good	Mostly well marked with one or two confusing turns.	Easy access trail on north side of the wall with well marked cairns. There is supposed to be a trail to the south but unable to find - it may be accessed from the wash to the south.
Six Star Wall	No Trail	No Trail	Long walk or high clearance vehicle required to access. Accessed by walking down a wash and then scrambling up the talus.
Slug Wall	No Trail	No Trail	Long walk required up a wash. No trail.
South Six Shooter Peak	Partially Good	At least four trails - all difficult to find if you've never been there	Long walk or high clearance vehicle required. Four trails. Cairns litter the slopes. One is accessed from in between N & S six shooters - in poor condition/does not exist. The other three are accessed from Davis Canyon Road and washes to the east & south.
Sparks Wall	Good	Well marked after trailhead	Start of trail hard to find from a pulloff from Beef Basin Road, but once on it, the trail is of good, but steep quality. A second trail to the north leads to ruins.
Suburbia	No Trail	No Trail	Access from The Wall parking area. No Trail.
Supercrack Buttress	Good	Mostly well marked.	The main trail is very easy access and easy to follow, but gets braided about 15 yards from the wall. A second very faded trail can be found in between Donnelly Canyon and Supercrack areas.
Technicolor Wall	Good/Poor	Three ranging from good to poor	Three trails. The east trail is extremely steep and loose - this is the one the guidebook recommends. The central one is excellent quality with only a couple loose sections - not easy to know where it is unless previously been there. Scattered cairns also mark trails on the west side.
Tenderloins	Good	Great in sections, but mostly crumbly trail	Long walk or high clearance vehicle required. Trail very easy to follow once at the trailhead.

Climbing Area	Overall Trail Condition	Quality Comments	Access Comments
Tricks Wall	No Trail	No Trail	The guidebook recommends walking across fields to access this wall; however this would require walking across private land. It could also be accessed by walking past Way Rambo down an old road.
Vitamin D Wall	No Trail	No Trail	Accessed by walking up a gully and scrambling up talus slopes.
The Wall	Good	Crumbling in sections	Long walk or high clearance vehicle required to access. Beginning of the trail is tough to spot since it starts down a gully, but after that it is easy.
Way Rambo	Partially Good	Braided trails	Easy to find for most of the trail but gets braided and confusing about halfway up the slope.